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THE POPULAR Science Review

EDITED BY W. S. DALLAS, F.L.S.

Assistant-Secretary of the Geological Society.

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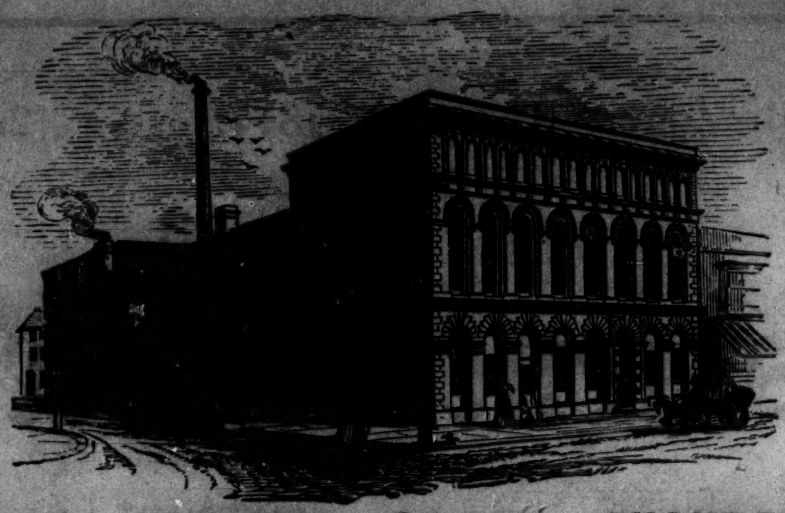

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POPULAR SCIENCE REVIEW.

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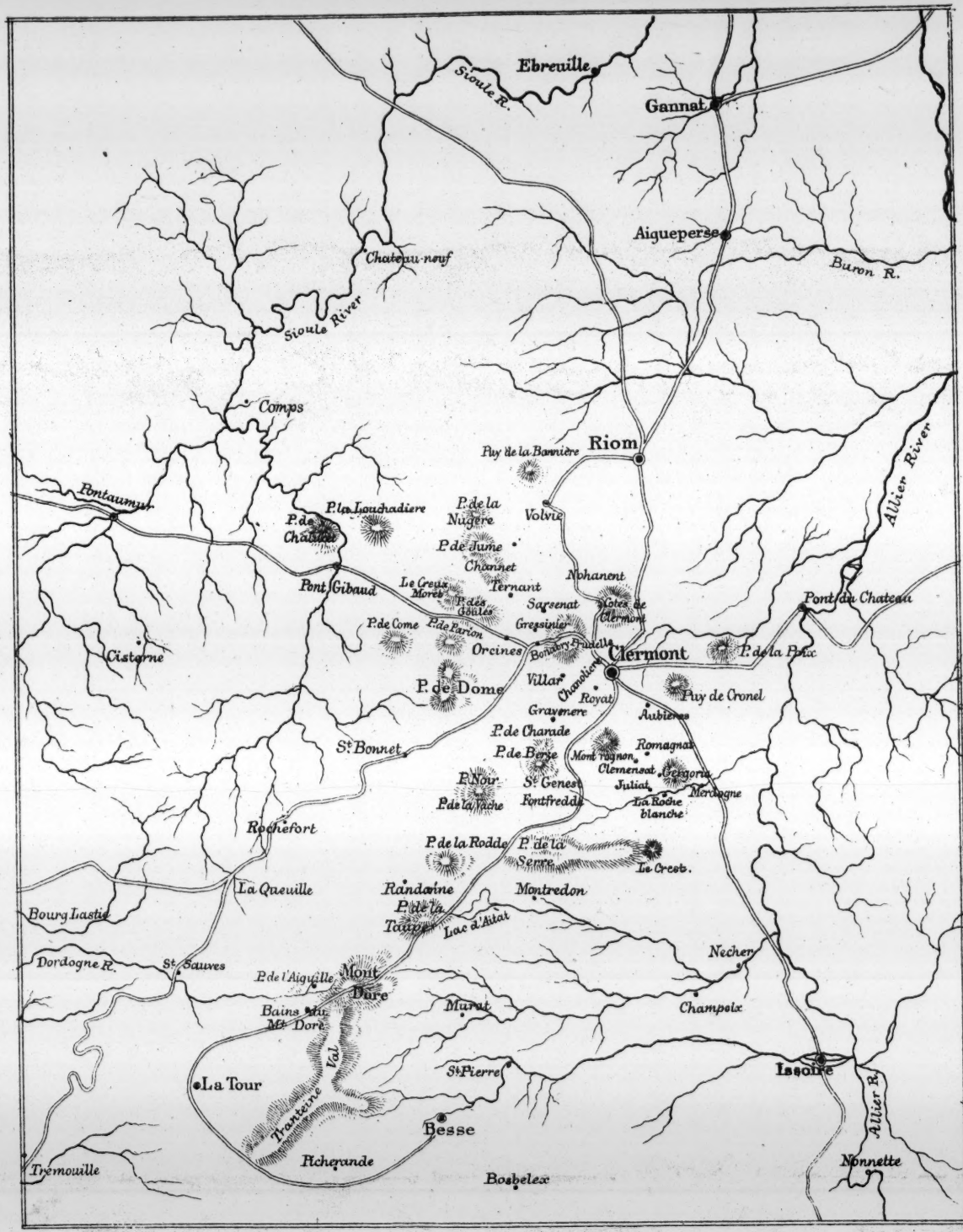

Sketch Map of Auvergne, by M.B.

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POPULAR SCIENCE REVIEW.

AMONG THE VOLCANOS AND GLACIERS OF AUVERGNE.

By the Rev. W. S. SYMONDS, of Pendock.

[PLATE I.]

IN Central France, as is well known, some very interesting volcanic phenomena are displayed in the country of the Auvergne and Ardèche. These volcanic phenomena must once have exhibited igneous activity upon the very grandest scale, and I have little doubt the igneous forces have been renewed from time to time from the eocene epoch of Sir Charles Lyell down to a comparatively modern period. Having visited this country now on three separate tours, in company with my friend Sir William Guise, and accompanied on the last occasion by Sir David Wedderburn and Mr. Lucy, members of the Cotswold Club, I would call the attention of our brother geologists, through the pages of the "Popular Science Review," to certain phenomena we thought worthy of stricter attention than it was in our power to give, and at the same time I will endeavour to give some information as to the best way of seeing, in succession, the grand displays of geological phenomena presented to our view. In the regions of the Mont Dore and the Cantal we find the relics of vast insulated volcanic mountains, like Mount Etna, which have been dormant for ages, and which everywhere exhibit proofs of the enormous denudation they have undergone since their lava streams flowed from their craters, or the lighter materials, such as scoriæ, pumice, tuffs, and volcanic ashes enveloped their cones. Atmospheric agencies, snows and frosts, streams and rivulets, and, in later times, the glacier, have utterly obliterated the volcanic cones, and these old miocene volcanos are laid bare even to their most inmost recesses.

Again, in the Chain of "Puys" near Clermont Ferrand, or the *Monts Dôme*, as also in those near the picturesque town of Le Puy in the Haute Loire, and near Vals, Montpézat, and Aubenas, in the Ardèche, we have examples of cones of igneous eruption which are of very recent date compared with the miocene volcanos of Mont Dore and the Cantal. Like the Vatna Jokull in Iceland, as described by Mr. Watts, the Monts Dôme must have formerly been a nest of volcanos, and the region around 'a country mourning in ashes and howling with desolation.' But comparatively recent as have been the volcanic outbursts of the Puys de Dôme, compared with those of Mont Dore and the Cantal, sufficient time has elapsed for streams to cut deeply into their most modern lava currents; vineyards cluster on their hill-slopes, beautiful woods grow in the rock gorges, and very old churches are built of the lava rock which once flowed in molten streams from their craters; while the fig tree bears its fruit where the ashes of the volcanos must have once darkened the air.

Before the geologist directs his attention to the district round Clermont Ferrand we recommend him to examine first the environs of *Moulins*, where are displayed the most northerly extensions of the sediments of that great freshwater lake of La Limagne d'Auvergne, whose waters once extended from Moulins in the north to Brioude, near Le Puy, in the south. Moulins itself is a quaint old place, through which the Allier flows wide and free, a very different stream from what we behold it when rushing among the hills of the Haute Loire. The great plain of the ancient fresh-water lake widens out as we proceed southwards, and in the summer-time green vineyards cover the lower slopes of the hills which rise above it. *Gannat* also requires especial attention on the part of the geologist, for both here and at Moulins there are indications of tertiary beds older than those in the Clermont Ferrand country. The Gannat beds furnish vast numbers of the thin shells or valves of Cyprides, small crustaceans which lived in millions in the waters of the ancient lake. Mammalian relics, too, are found in the basement strata at Gannat, Moulins, and Le Puy en Velay, which belong to eocene genera, for among them are those true eocene animals, the Palæotherium and Hyænodon, which occur also in the eocene strata of Hampshire and the Isle of Wight. Again, we have to account, as Mr. Scrope has pointed out, for the difference of level in the freshwater beds towards the north at Moulins, and southward near Issoire, where they attain a height of 2,700 ft., while the elevation north of Moulins is below 1,000 ft. I imagine that the Moulins country was depressed, and that the miocene beds above the eocene have there been denuded.

At *Aigueperse* a higher series of strata overlies the Gannat

beds, and these would seem to be of miocene age, as they have yielded bones of miocene animals. As far as I understand, the Aigueperse beds are overlain by the indusial limestone, which is characteristic of Gergovia and other localities near Clermont Ferrand, and which is so termed from the abundance of the cases (or *indusiæ*) of ancient caddis worms which enter into its structure. These cases were once the abode of the larvæ of a kind of fly (*Phryganeæ*) which frequented the waters of the miocene lake in shoals. Around the tubes of the caddis worms are attached numerous minute freshwater shells (*Paludinæ*, &c.) which the caddis worms when living agglutinated to their tubes.

Clermont Ferrand is an excellent place for head-quarters, from which to visit many localities of high interest in Auvergne, especially as it now is possible to go to some of the best stations by rail at a small expense. The town itself is full of interest in respect to archæological lore. Here Peter the Hermit preached religious war against the Saracens, and here Pope Urban elevated the cross before the multitude, maddened by that religious enthusiasm which sent thousands to die in a distant land, "far o'er the waters of the dark-blue seas." The "Dieu le Volt" of that vast host must have re-echoed from hill to hill; while hundreds thronged within the walls of Notre Dame du Port, which still stand as massive as in the days of the Hermit. Here the Pope Alexander III. thundered forth his blasting excommunications against the Emperor Barbarossa. Again, Clermont Ferrand was the birthplace of the illustrious Pascal, who will be remembered long after Pope and Emperor shall be forgotten. Pascal was the first philosopher who established the law of atmospheric pressure at different elevations, but his experiments were interfered with by the Jesuits at the College of Clermont, who threatened him with charges of heresy; as he says in his "Pensées," "Les Jésuites concluent toujours que leurs adversaires sont hérétiques." In consequence of this persecution, Pascal had to employ his brother-in-law, M. Périer, who lived at Clermont, while he sought refuge in Paris, to carry out his experiments and take a barometer to the summit of the Puy de Dôme. It was thus that in September 1648 the effects of atmospheric pressure were established beyond all doubt; while this present summer of 1876 witnessed a concourse of representatives of all the nations of Europe, assembled round the noble observatory erected to Pascal's memory on the Puy de Dôme, a grand tribute to one of Nature's pupils.

The Cathedral of Clermont is built of the dark lavas of Volvic. Nothing can exceed the beauty of the decorated work executed in this lava, the grey colour of which is very pleasing to the eye. The choir is very striking from its height, as it

rises "on pillars lofty and light and tall." Beautiful, too, are the long lancet windows in the apse and those of the clerestory, which are for the most part filled with rich stained glass.

Notre Dame du Port is a truly curious church, said to have been built about A.D. 580. It ranks among the historical monuments of France, and through the very early character of its Romanesque architecture and sculpture is of especial interest to the antiquarian. The elaborate decoration in mosaic of its towers is believed to be of the best Byzantine architecture, and the sculptures on the tympanum of the south doorway are curiously rude and unusual. The church is barrel-roofed, with an apsidal termination. The crypt, which is under the choir, is said to be the most ancient part of the building, and is remarkable for its rude pillars and massive roof. Here, as at Le Puy en Velay, is a black Virgin, probably the Roman Catholic adaptation of some Eastern idol. The petrifying spring of St. Alyre was once celebrated for the miracles performed there. There are many other springs in Auvergne possessing incrusting qualities, but none of them incrust objects exposed to their spray in so short a period as that of St. Alyre. Both Dr. Daubeney and Mr. Scrope attribute the immense quantity of travertine deposited by the water to the volcanic action below, and believe that the springs were fuller when the subterranean forces were in greater activity. Of the various objects placed on shelves and boards for incrustation by dripping are stuffed animals, their hair all coated with carbonate of lime, and stuffed birds; but the really beautiful specimens are crayfish and land shells, which preserve their shape entire in stone. There are also baskets, artichokes, and bird's-nests, with brooches made from casts and alto-relievos. Some of the latter are taken from coins found at Gergovia. The "Pont naturel" is worthy of a visit, forming as it does a natural arch which is constantly increasing.

When staying at Clermont some years ago we visited the late distinguished naturalist and geologist, M. Lecoq, to whom we had a letter of introduction from Sir C. Lyell. We found him most kind and communicative as to the points best worthy of observation. His museum was a model of good arrangement and careful keeping. Especially was it interesting to us in its illustrations of the natural history of Clermont Ferrand and its neighbourhood, of the rocks and minerals of the district, the fossils, the flora, the birds and their eggs, besides a large conchological collection from all parts of the world. M. Lecoq entered fully and unreservedly into his own views of the geology of the lacustrine beds of the Limagne, the extinct volcanos and their lavas. With regard to the occurrence of the glacial epoch and its effects in Auvergne, he considered that some

erratics had been transported by the action of melting snow, but he had then failed to find any signs of glacier action among the Auvergne mountains. M. Lecoq further directed our attention to the remains of the Marmot and Mammoth, teeth and bones of which animals he had obtained from crevices and cracks in the most modern lavas, such as those of Beaumont, Royat, and Volvic. We visited this museum again this summer, and saw completed that grand map of Auvergne which was coloured by this great naturalist with his own hands. Alas, that hand lies now cold in the tomb, and we missed sadly the courteous welcome and kindly explanations of many a relic rich and rare. His fine museum M. Lecoq left to his fellow-townsmen, a monument to his memory of an undying nature. The town museum contains a valuable collection of Roman amphoræ, utensils, and coins, some of which were found during the excavations made at Gergovia by the orders of Napoleon III. when writing his "Life of Cæsar." There is, too, a fair collection of stone implements, and the worst collection of daubs of oil paintings under the sun.

There is no greater mistake than to suppose that a walk to the Puy de Dôme, Pariou, and Graveneire will enable the geologist to comprehend the geology of Auvergne! Everyone should be possessed of the admirable work by Mr. Poulett Scrope on the "Extinct Volcanos of Central France;" yet even with this book at hand for reference it is not easy for those whose time is limited to select localities which will enable the tourist to grasp the striking geological phenomena presented by volcanic outbursts of long separated ages; of lacustrine formations of lakes now denuded 1,000 ft. in depth; of old river gravels far above the present river levels; and lava currents which once occupied valleys and gorges now standing out as mountain outliers, and cut clean away from the mass to which they originally belonged. I think that anyone who has, say, a fortnight at his disposal, would do well to devote his first attention to the granitic plateaux, through which the volcanos of the Puys de Dôme have been erupted, and those valleys and glens which had been eroded in the granitic rocks forming the old country before the outburst of the volcanos, and down some of whose valleys the more modern lavas have flowed for miles.

Granite Plateau.—A reference to the geological map of Central France shows a large tract of elevated country principally composed of granitic rocks set in a framework of strata of Jurassic age. It is evident also that granitic rocks constituted the *old land surface* through which burst the great miocene volcanos of Mont Dore and the Cantal, and that granite mountains formed the shores of the ancient eocene and miocene lakes. For the investigation of portions of the granitic plateau

near Clermont we recommend the walk through the village of Chamalières to Royat. The church of Royat is old and singular, and exhibits portions of early Romanesque architecture, and the village and valley are extremely picturesque. The lava which has been poured down from Graveneire into the valley is well displayed in a fine section near the "grotto," and a walk up the stream will afford a good idea of the excavations through the lava effected by the rivulet. Opposite Royat there is a quarry called the "Carrières Blanches," where a felstone porphyry is injected into the granitic rocks of Villar, and, protruding at the surface, forms a boss. Here we found growing, in May last, a large purple *Iris*, with *Anemone montana*; and many swallow-tail butterflies were chasing each other in the sunshine round the knoll. From thence we pursue the route to the hill of *Graveneire*. There is no crater; but immense masses of red and black scoriæ, lapilli, and pozzuolana, quarried for their materials, look as if they had been ejected yesterday, and tell the tale of igneous action as would a blacksmith's forge. The volcanic masses appear to have been erupted through fissures in the granite hill known as the *Puy de Charade*, and three streams of lava flowed down the slopes. Besides the Royat lava stream on the north, two streams flow towards the east and south. The eastern current was turned aside out of its course by the *Puy de Montaudoux*, a rock of basalt of far more ancient date, and which occupied its present position for untold ages before the volcanic outbursts of Graveneire had commenced. From Graveneire we recommend the walk to the Puy de Berzé.

The Puy de Berzé is more than 3,000 ft. above the sea, and its summit is capped by basalt overlying granite. We here remark the difference of position of this old lava as compared with that of the valley of Royat. Mr. Scrope thought that the basaltic currents which overflowed the freshwater beds of Gergovia, and the isolated Montrognon which forms so striking a feature in the scenery of Clermont, had their source in an aperture near the summit of Berzé, and flowed downwards into the lake, overflowing the lacustrine silts and their shells, where now stand Gergovia and Montrognon. Again, at St. Genest, there is a little valley with a rivulet into which has been poured a stream of columnar basalt with veins of quartz; and we see that the granitic mass had been here eroded before the outflow of the basalt. On the road to Montrognon and Clermont the granitic rocks are much disintegrated by the action of the atmosphere, and present appearances which might easily be set down as due to ice action. The rocks here and there by the roadside look as if they were *moutonnées* by ice; while the granitic masses separating at the joints form rounded boulders,

assuming precisely the aspect of *blocs perchés*. Another route across a granite country is to go by Chamalières over the Plateau de Prudelle by Sarsenat to Channat, and then to return by Nohanent and the Côtes de Clermont.

At Prudelle, at the height of 2,313 ft. above the sea, we find an ancient columnar basalt resting on granitic. The valley of Villar has been excavated in the granitic rocks since the overflow of this basalt, and down this valley has flowed the modern lava current from the Puy de Pariou. The geologist will not fail to remark the difference of position between the older and more modern lava currents. It is a good walk eastward across the granite country to the Puy de Channat, which is worth examining, as the recent volcanic masses have been blown right through a granite platform in advance of the line of the Puys de Dôme.

The Volcanic Outbursts of the Puys de Dôme.—Le Puy de Dôme is the great excursion from Clermont, and every geologist will ascend this noble mountain, which towers to the height of nearly 5,000 ft. above the sea, and is so striking an object from every point of view in the surrounding country. From its summit and observatory he will also gain some idea of the geography of the wonderful region around him, and mayhap from the grand panorama somewhat of its geology. There are volcanos all around, red with volcanic ashes, and craters yawning on their sides or peaks. There are hills rising high above the vales, which owe their protection to lava streams which flowed in ages so long ago that the volcanos which emitted them have been utterly swept away by denudation and degradation, or what was left has been obliterated by later volcanic outbursts. Then there are valleys which have been scooped out since the older basalts flowed, and these again bristle with lava torrents poured forth from the modern volcanos, which run in a line north and south from the Puys de Dôme. On the flank of the mountain itself blossom beautiful wild flowers. The noble yellow Gentian (*Gentiana lutea*) and the Martagon Lily (*Lilium Martagon*), with *Melittis grandiflora*, *Arnica montana*, *Ashantia major*, *Rhinanthus major*, and a score of other plants, were found by us in the sunny month of June, though snow still lingered on the heights of Mont Dore away to the southwards. Then there are rivers sparkling in the vale, and great hills looming in the distance, with hillsides clothed, some with forests, some with vines, and others bare and scorched as if by volcanic fires still slumbering beneath. Clouds gather over one distant range, and the sunshine lights up another, and you hear the thunder muttering from afar, while from below comes the tinkling of the sheep-bell, or a neighbouring church bell clangs through the still clear air. There is much to be seen from the Puy de Dôme.

Nevertheless, I cannot recommend the geologist to delay over its geology unless his time is of no importance. Mr. Scrope thought that the "Domite," or trachytic mass of which it consists, is of the same age as the volcanic products of the Puy de Pariou and Puy de Dôme. M. Lecoq assured us that he had arrived at other results, and was of opinion that the Domite belonged to the age of the trachytic lavas of Mont Dore, and that the newer Puys and their outbursts were erupted through and among the "Domite." If I may venture to pronounce an opinion, I should prefer the explanation of M. Lecoq. When we find a great extension of old basalts, apparently of the same age as the Mont Dore basalts, extending right away from Montredon on the south, by the Plateau of La Serre; again between Channat and Ternant; and as far northwards as Lague, south of the Puy de Jume, it is impossible to avoid the conviction that there was a great line of volcanic outbursts along the line of the Puys de Dôme of much earlier date than those late eruptions. But whether this supposition is right or not, none of the Puys just mentioned furnish such satisfactory displays of lava torrents and other phenomena as do the Puy de Pariou and many others. The Puy de Pariou is remarkable for its perfect crater, and is within a short walk of the Puy de Dôme. It is well to trace the lava current downwards to La Baraque, and observe the island of granite which it surrounds at Orcines and the check it meets with at the junction below Bonabry from the old basalt of Prudelle. When visiting Pariou in May (1876) we found the rim of the crater studded with the beautiful *Anemone montana*, with its maroon-coloured petals and bright yellow stamens. Below, near the outburst of the lava current, we gathered *Anemone ranunculoides*, *Corydalis solida*, *Scilla bifolia*, *Orchis sambucina*, *Pulmonaria officinalis*, *Daphne mezereum*, and a large variety of *Primula elatior*. Sir David Wedderburn made the depth of the crater by aneroid somewhat less than does Scrope, viz., 300 ft. A small *Viola* grew in abundance in the crater. From our notes, on a former visit in the month of July, I find that *Cephalanthera rubra* was found in the crevices of the Pariou lava current; this plant is extremely rare in England, having only been gathered on one locality of the Cotswold Hills in Gloucestershire, and in one copse in Somersetshire. Here, too, grows a peculiar rose with glaucous foliage and red stipules much dilated (*Rosa rubrifolia*?), and the guide asserted that it would not bear transportation. We gathered also *Lychnis viscosa*, a plant which grows too on Stanner Rocks, an ancient volcanic rock which traverses Silurian limestones near Kington in Herefordshire.

Another expedition among the more recent volcanic phe-

nomena may be made along the Pont Gibaud road as far as the Creux Morel, to examine the volcanic hollow near the Puy des Goules, and thence to strike westward for the Puy de Côme. This volcano rises more than 900 ft. above the plain. It has two craters, one 260 ft. in depth. The lavas which have flowed from it have spread over an area of 10 square miles, and its cinders cover the plain of the Creux Morel. The lava torrent may be traced from its source to the granitic peninsula east of Chambois, where it divides into two streams, one flowing over a vast platform towards Pont Gibaud, the other taking the direction of Mazayes. It is worth while to remain for a night at Pont Gibaud and examine the flow of the lava over sites where now are the village and castle; the meeting of the lava streams from Le Puy de Louchadière with that from the Puy de Côme; and the fine section of the valley of the Sioule river below Pont Gibaud. The Puy Rouge, near Chalucet, two miles from Pont Gibaud, has poured forth columnar basalt into the river, and there is a remarkable display of recent-looking scoriæ and volcanic bombs round the volcano itself.

Another excursion among the more recent volcanic rocks is to Volvic and the Puy de la Nugère. The rail takes us to Riom, and the walk from thence is full of interest. On the right are the picturesque ruins of the Castle of Turnuoel, and high above Volvic is a gigantic effigy of a Madonna, carved in Volvic lava, and 30 ft. high. The lava current of Volvic which flowed from the Puy de Nugère has been quarried since the days of the Romans, and is often studded with laminæ of specular iron. Tracing it upwards through a wood and narrow pass, we enter upon a broad valley, and see the lava encircling a low hill of granite; and following its course up to the volcano we find the Puy de Nugère, a cone with a deep oblong crater, and the lava pouring down the steep sides of the mountain. The geology of the Puy de la Bannière is quite different from that of Nugère. There is no crater; but masses of scoriæ and streams of lava have been erupted through a fissure in the granite plateau which stretches away for miles to the north, and overhangs the fresh-water beds of the lake of the Limagne, as it must have done when the waters rolled where now flourish the corn-field and the vineyard, and when the strange quadrupeds of miocene times frequented the granitic mountains and the shores of the great lake. On this hill, to the east of the figure of the Madonna, is a fissure, out of which has burst scoriæ, pozzuolana, and a thin lava stream, which seems to pass under the old Romanesque crypt of the church at Volvic. That rare British plant *Scleranthus perennis* was very abundant at this spot in the month of July.

One more expedition among the later volcanic hills and lava

currents we must not fail to recommend. This is to *Randanne*, and it may be taken *en route* to Mont Dore les Bains. Opposite the little hostel is a kind of summer-house, with very comfortable bedrooms, where quarters may be had for a night or two. This is a most extraordinary scene, when viewed from the summit of one of the volcanic Puys, and was selected by the Count de Montlosier as his home on his return to France in 1820, after many years of exile. His "Essai sur la Théorie des Volcans d'Auvergne" was published in 1789, and thirty years afterwards he returned to spend his last days among the mountains of the Puy de Dôme. He planted woods and cultivated the sterile soil, and when he died he was refused burial by the bishop of Clermont. This persecution was on account of his having written against the Jesuits in early life, urging them to use a cross of wood instead of one of gold, saying "c'est la croix de bois qui a sauvé le monde."

In May last we found the wood of Randanne, before entering the village, actually carpeted with spring flowers. There were violets, and primulas, and *Anemone montana* in thousands, *Anemone ranunculoides* and two or three orchids. The July list of Sir William Guise gives *Trifolium alpinum*, *Saxifraga stellaris*, *Sedum villosum*, *Geranium phœum*, and *Centaurea montana*.

The Puy de la Taupe rises close to the village, and a lava stream has flowed from its western flank. The view from thence right into the craters of the Puys to the north, backed by the distant Puy de Dôme towering above all, can best be characterized by the term weird. The Puys de la Rodde and de la Vache should be especially visited. Their craters, and the way in which their lava streams dam up rivulets and give rise to the lakes of Aidat and la Caissière must be seen to be comprehended.

The Older Basalts and Freshwater Beds of the Limagne.—We now revert to the older basalts, the products of much earlier volcanic eruptions than those we have just indicated, and masses of which are to be found capping many of the hills in Auvergne, sometimes more than 1,000 feet above the plains of the Limagne.

The Plateau de Prudelle is a mass of this ancient basalt, which overlies granite, and is within a short walk of Clermont. Two valleys, Villar and Gresinier, have been eroded on the south and north, down which have flowed recent lava streams from Pariou; but the old basalt of Prudelle has protected the granite promontory it overlies, and granite and basalt now stand out as grand witnesses of the gradual erosion of valleys, the resistance of hard lava, and the antiquity of the basalt. But the basaltic plateau, *par excellence*, for investigation, is that of

La Serre. The best way of reaching it is to drive or take a Mont Dore diligence to *Fontfredde*, a most interesting little valley, where a current of recent lava from the Puy Noir flowed, where now runs a stream, and rolled for ten miles down the valley of Théix to Julliat, near La Roche Blanche, and Le Crest. Crossing the stream at Fontfredde we walk over decomposing granite, and find ourselves on a great sheet of old basalt nearly two miles broad and ten in length, exhibiting all the characteristics of those wider basaltic platforms which we see in the Mont Dore country, in the Cantal, and in the Ardèche. The highest point, the Tête de la Serre, is nearly 3,500 ft. above the sea, and that accurate observer Mr. Scrope gives all the particulars of its characteristic features, the origin of its lava current in the granite, the flow of the lava down an inclined plane, the scoriæ on which the basalt rests, the denudation round the mass of granite on which stands the insulated basalt and castle of Montredon, and the proofs of four distinct steps in the process of excavation and denudation since the outflow of the lava of La Serre from the granite. Our advice is to trace this lava current from its source among scoriæ, masses of granite and volcanic bombs, to Chadrat, where it overflows freshwater beds of oolitic structure, and from thence to the picturesque village of Le Crest which alone is worth a visit.

Freshwater Beds and their Fossils.—Before visiting Auvergne I advise every lover of geology to give a day or two to the examination of the wonderful collection of the remains of fossil mammalia from the old freshwater beds of the Limagne, in the museums of the Jardin des Plantes in Paris. Nearly one hundred species of different quadrupeds have been found in the old lacustrine silts of Auvergne and Velay. Among them are great herbivora, such as mastodons, rhinoceros, tapirs, and deer, which ranged on the plains and pastured in the forests; and with these were great beavers, which lived in the rivers and lakes. There were beasts of prey allied to the tiger, hyæna, bear, and wild dog; and with these were associated large crocodiles and tortoises, snakes and frogs. Several extinct species of birds have been determined, allied to our swans, ducks, gulls, and swallows, and even the eggs of some of the water birds have been fossilized and preserved. These animals belong to miocene times, and should not be confounded with the eocene animals of Gannat, or the pliocene fauna of Mont Perrier near Issoire.

A fine section of the freshwater beds with their protecting cappings of ancient basalt is displayed in the well-known hill of Gergovia within a six-mile walk of Clermont. Gergovia is famous in history as the stronghold of the Arverni, who, under their brave chief Vercingetorix, defended it so gallantly against Julius Cæsar and his Roman legions. We visited Ger-

govia some years ago, soon after some excavations had been made, on the occasion of the visit of Napoleon III., when many Roman and Celtic relics were discovered. The best plan to attack Gergovia from Clermont is to drive by Beaumont and Aubières to the base of the hill. The superficial drifts of Beaumont have furnished the bones and teeth of mammoth and *Spermophilus*, a kind of marmot. The best sections of freshwater beds are on the northern and north-eastern flanks of Gergovia; and we recommend the searcher for fossils to walk up the stream from Romagnat by Clemensat, and then strike across for Gergovia. At the base of the series there occur the fossil snail shells (*Helix*) that are so abundant at the base of the Puy Dallet; and here M. Lecoq obtained freshwater mussels (*Unios*) while above rest the indusial limestones full of the cases of the larvæ of caddis flies, surrounded by minute freshwater shells. The eastern face of the camp is perhaps the best for seeing the position of two outflows of basalt and the deposition of lacustrine silts and fossil remains between the basaltic outflows. To the southward is a dyke through the freshwater beds, and this seems to be the site of a chimney by which volcanic materials were injected into and over the lacustrine silts.

On reaching the summit of Gergovia we arrive on a plateau about a mile and a half in length from west to east, by perhaps half a mile in width. It exhibits now no trace of the old Gaulish city, although the plough frequently turns up coins, and pieces of coarse pottery are often met with. The south face of the hill is evidently scarped, and the remains of a rude stone rampart of basaltic blocks may be traced. It would seem that the north face was sufficiently protected by the abrupt and precipitous character of its basaltic rocks. The platform is penetrated from north to south by five narrow rude roads, probably the ancient Viæ.

The prospect from Gergovia is truly grand and interesting, not merely on account of its extent, but from the variety of form, colour, and contrast due to the geological configuration of the country. On all sides rise isolated hills, some of them surmounted by fortresses, built in almost inaccessible places, by the feudal lords who were ever ready for warlike and violent deeds. These unruly barons were at last put down by Louis XIII. and Richelieu, and their strongholds destroyed. Such was Montrognon, which is close to the N.E.; and Montredon, which lies a little W. of the great basaltic platform of La Serre, of which it is an outlier.

The best descent from Gergovia is by the S.E. side of the camp, where a dyke of volcanic ash, scoriæ, and masses of lava have been ejected through a fissure in the freshwater beds, and through the lower basalts; and the protrusion of this dyke has

greatly disturbed and altered the beds at the point of contact. The freshwater beds may be seen tilted at a considerable angle, and when in contact with the lava have been altered into a hard compact limestone, with conchoidal fracture. At a considerable distance below the upper basalt of the platform a thick bed of consolidated volcanic ash is seen resting upon the freshwater limestone; it has put on the appearance of a lava bed, but the freshwater strata below it do not seem in the least altered.

We have not space to indicate half the interesting points to visit round Gergovia, but we may advise our brothers of the hammer to take an omelet at the little *auberge* at Merdogne, which is believed to be the locality noted by Cæsar in his account of the attack on Gergovia, according to the plan published in Napoleon III.'s "Vie de César." The hill above the village of La Roche Blanche is recognised as the "Collis sub ipsis radicibus Montis," which Cæsar seized by a night attack, and connected with his principal camp by a double foss; and Merdogne is fixed upon as the ground where Cæsar stationed himself with the 10th Legion, and from whence he caused the retreat to be sounded. I also would direct attention to the mass of subangular drift with large angular masses of rock contained in it, which occurs in a cutting of the road between Merdogne and the high road to Clermont. The northern shoulder of Montrognon looks as if volcanic masses had flowed down the slope *since the isolation* of that remarkable hill from that of Gergovia, with which it must once have been continuous. The geology of Montrognon is a good deal masked by the fallen ruins of the fortress and the weathering of the basalt.

Another expedition from Clermont for the older basalts is to go by rail or drive to Pont du Château for the Puy de Dallet. Driving, we pass on the right the Puy de la Poix, a local outburst of volcanic matter, into the lacustrine marls of the ancient lake. A great quantity of bitumen is associated with calcareous fragments, volcanic peperino, and vegetable matter. The Puy de Crouel and the hill of Clermont are both supposed to have the same origin as the Puy de la Poix, viz., the outburst of lava into the waters of the freshwater lake among masses of driftwood and other vegetable matter. At Pont du Château, on our visit in May last, a quarry opened at the end of the village before descending to the bridge over the Allier, exhibited a section of what was evidently a volcanic vent into the freshwater beds, showing that at this point also volcanic eruptions were going on during the formation of the lacustrine silts at the bottom of the lake. When here some years ago, in the month of July, we were walking up the right bank of

the Allier to Scrope's celebrated river section, when we were struck by what appeared to be, at a short distance, some large bright blue flowers. On approaching them they proved to be dwarf elder bushes (*Sambucus niger*) covered with a quantity of small azure chafers (a species of *Hoplia*), a beautiful insect much used in Paris and other towns for brooches, necklaces, &c. So numerous were these blue chafers that the panicles of the elder-flowers were studded with them, and presented a remarkable spectacle.

Scrope's section of the cliff on the banks of the Allier at the base of the Puy de Dallet is well known, and the principal point to direct attention to is the lowest bed, exhibited when the river is low—which it was not at our last visit. It is a limestone, charged with volcanic fragments as if there had been a volcano on the borders of the lake, which erupted an abundance of scoriæ. Over this lies a limestone full of the casts and remains of land and freshwater shells, some of them snail shells (*Helicidæ*) washed into the lake; others freshwater shells, such as *Planorbis* and *Lymnæa*, which lived in the waters. It is probable that these beds on the Allier represent those at the base of Gergovia, where also *Unios* are found. The highest bed of the section is full of volcanic matter. The beds dip westward, and behind the cliff we see the isolated mass of the Puy de Dallet, composed of strata similar to those of Gergovia, though so masked by vineyards and cultivation that it is difficult to make out their succession. The basaltic platform, too, is much broken up at the surface by atmospheric action and decay. The observer will see the cliff near the road to the village of Dallet, capped with a river drift of an ancient Allier, which flowed far above the present river level. Again, he will not fail to remark a road section before descending the hill to Dallet, where a thick mass of atmospheric drift overlies the old river-bed, and that this must have accumulated under different circumstances to the present.

The Mont Dore.—The road from Clermont to Mont Dore passes by Montrognon and the *moutonnée*-looking granitic rocks to Fontfredde and Randanne, which is the place for the traveller to make inquiries about ponies or horses when at Mont Dore les Bains. So late was the spring of 1876, that between Randanne and the Rochers Sanadoire and Tuilière we passed pine woods with numerous branches lately broken off by the weight of May snows, and hardly a plant showed its blossoms along the great tract of ancient lava currents over which the road passes. We passed some time in the examination of those well-known rocks—the Rochers Sanadoire and Tuilière—and there are none more grand and picturesque in the Mont Dore country. They rise like giant pyramids on the opposite

sides of a lovely wooded glen—sentinels to the approach to the old volcano. They consist of columnar phonolite, and it is impossible to describe the beauty of the shaft-like columns of Tuilière. Some of the columns are curved, and slates are quarried at Tuilière in cleavage planes, which are at right angles to the axis of the columns. We remarked, too, the inter-bedding of yellowish, soft, trachytic ash, with beds of hard basalt on Puy Gros. This soft trachyte weathers out easily, and its consequent denudation is the cause of the beautiful valley scenery we drive along *en route* to Mont Dore les Bains. Lake Guery, which is passed on the right, is famous for its red-fleshed trout, and the lake itself is walled in by basalt from the Puy Gros. It is from the Puy de l'Aiguiller, on the north, that the great lava current has issued which stretches for a distance of fifteen or sixteen miles along the banks of the Sioule river, and covers the granitic plateau at Pont Gibaud. Those who visit Pont Gibaud from Clermont may thus gain some idea of the extension of the ancient lava currents of Mont Dore.

It is impossible to give a better description of Mont Dore than that of Scrope, viz., a great volcanic mountain like Etna or Teneriffe, which has been reduced to a mere skeleton by the wear and tear of long ages of denudation; and no geologist can cross its peaks and cols, traverse its lava currents, explore its valleys all round the base, as we have done, without seeing how the upper and softer materials of the volcano have been swept away to form conglomerates and breccias, which have been carried for miles, and the very innermost dykes and porphyritic masses of the inner structure have been laid bare.

With regard to the volcanic structure of Mont Dore the phenomena are far too vast and varied to be treated of here; but we may say that a steady examination of the valley of the Dordogne on one side, and the valley of Chambon on the other, will go far towards giving the physical geologist a good idea of its history. Scrope's section of the Cascade du Mont Dore, with its succession of soft trachytes, interlaced with hard lavas and basalts, is a good lesson in volcanic structure; while the study of the valley of the Dordogne from side to side, and the evidence that it has once been filled with volcanic materials to the level of the upper basalt, and has since been eroded to the depth of 800 ft., is a lesson on the denudation and erosion of the other valleys.

We visited Mont Dore in May, 1876, for the purpose of examining into the evidence of glacial action, and the former existence of ancient glaciers in Central France, suggested by Dr. Hooker, of Kew, in a contribution to "Nature," of Nov. 11, 1875. The glacial appearances due to weathering among the

granitic rocks of the Monts Dôme had made us all, perhaps, over careful, and we were none of us the least inclined to make lateral moraines of mere local *débris* or *roches moutonnées* of weathered granite.

The valley of the Dordogne was yellow with the flowers of *Primula elatior*, and the bright blue blossoms of *Gentiana verna* were glistening on the slopes of the Cascade side by side with *Thlaspi alpestre* and purple pansies (*Viola tricolor*); but the heights of Puy Ferrand and the Pic de Sancy were white with snow, from which a thousand streamlets poured, laden with detritus, and affording an excellent illustration of the power of melting snow in carrying detritus from mountain slopes to a lower level. In fact, the valley of the Dordogne is now every spring-time everywhere percolated through and through by running water, and if there was a glacier there, in days long ago, the numerous streamlets produced by the melting snows and rains must have long ago sorted the glacial *débris* and rolled and washed the materials.

The masses of rock known as "Les Trois Diables" appear to be fallen masses, and the bristling pinnacles of the Gorge d'Enfer called "Les Cheminées du Diable" are about soon to follow their example and hurtle downwards into the abyss below. The wind was bitterly cold at the Gorge d'Enfer, and the snow lay deep in its gullies. Here and there the rosy blossoms of *Androsace carnea* looked like blood-spots among the snow, on which we picked up a dead Brambling finch (*Fringilla montifringilla*), which had succumbed to the cold. Passing over a *coulée* of snow, I ascended to the basaltic platform above, and there saw masses of trachyte and felstone resting on basalt, which could hardly be fallen *débris*, and I was thus led to believe that a glacier had passed over the higher platforms of basalt *before the erosion of the valley*. I also called the attention of my companions to what I think is moraine matter, and transported rock masses of trachyte resting on basalt, on the road between Mont Dore les Bains and La Cour, as on the basaltic platform below the Rochers de Beauzac.

Above the entrance of the valley of La Cour we cross the Dordogne and wind up the zigzag towards the Pic de Sancy. Opposite to the "Vallée de la Cour" is a deep gorge, dividing the Cacadogne and the Roc du Cuzau, and from this gorge rises the "Roc Barbu," a mass of columnar basalt which is interesting, as it was believed by Scrope to occupy nearly the site of the great crater of the ancient miocene volcano. No one can examine into these inner recesses, and afterwards explore the volcano round its base, and observe the enormous masses of volcanic materials spread forth from a common centre, without becoming convinced, first, that the formation of the volcano

must have occupied a long period of volcanic activity; and secondly, that the destruction of its original shape must have been caused by long ages of quiescence. Had the volcano continued in action, the effects of erosion would soon have been obliterated; while the deep valleys and gorges tell of long continued denudation since the last outbursts from the Mont Dore crater.

Our route to the Tranteine valley passed over the Col between the Pic de Sancy and Puy Ferrand, and our guide was Guillaume Pierre, of the Hotel Chabory ainée, whom we can recommend, and to whom I pointed out various phenomena in the Tranteine gorge which I commend to others who have time at their disposal for examination.

The head of the Mont Dore valley is a semicircle of precipitous mountains, buttressed with jagged dykes of hard trachyte and columnar basalt, and intrusive masses of felstone porphyry. Looking northwards we behold the deep valley and amphitheatre of the Dordogne, and huge pinnacles of rock which shoot up from the lateral Gorge d'Enfer. Far and wide the eye beholds volcanic hills, many so bare of vegetation as to give the distant view an aspect of sterility. At one point you see the modern volcanos of the Monts Dome; at another you look upon the older volcano of the Cantal, glistening with snow as if to assert its more hoary longevity as a patriarch of other days. The gorge of Chaudefour opens out to the north-west, below Puy Ferrand, and we look down on bristling rocks, sheets of basalt, the valley of Chambon, the old castle of Murol, and the modern volcano of the Puy de Tartaret, with the lake of Chambon dammed up by its lava current. The Tranteine valley runs due south, and faces the country of the Cantal. High above its northern gorge rises the Pic de Sancy surmounted by a cross. The Pic itself owes its shape and preservation to the slow weathering of a hard felstone porphyry, which Mr. Scrope calls a "porphyritic trachyte," and which is important to bear in mind as a good local rock to mark for evidence as respects transportation, like the granite erratics of Mont Blanc.

The transported rock masses sketched by Dr. Hooker in "Nature" are distant a mile and a-half from the summit of the Pic de Sancy, and I took the guide from the Col at the head of the pass down the gorge. Nearly in the centre of the gorge we came upon a *roche moutonnée*, close by which flows a rivulet; and on both sides the hills, as they slope downwards towards the south, are studded with perched blocks resting on masses, *in situ*, of different mineral composition, and of which the only way of accounting for the distribution, save that of a glacier, is that they may have been shot out of the volcano and,

fallen where they lie. The transported blocks described by Dr. Hooker are stranded against a low sloping hill at the mouth of the gorge. This low hill consists, as shown by sections in the streamlets, of basalt and moraine matter. In the moraine matter, Dr. Hooker found scratched and polished stones. No one can examine the section below the waterfall of the Tranteine stream without seeing that the great blocks are masses transported from the upper part of the gorge, resting in moraine matter, and on sheets of basalt. The larger masses consist of felstone porphyry from the Pic de Sancy, but there are others of trachyte and basaltic lava which show signs of great weathering. On the right and left of the transported rocks the hills are weathered and rounded, and have *blocs perchés* resting on them. Here, as far as I read the history, rest the relics of the last of the glaciers among the valleys of Mont Dore, stranded against the low hill which a glacier of larger size once swept over and stretched far down the valley towards Latour and Picherande. But why should glacier relics be preserved so well in the Tranteine valley and obliterated in that of the Dordogne? It is accounted for, in my opinion, by the great difference in the watershed of streamlets and the freedom, comparatively, from the constant wear and tear of tributary rills of water rushing through the glacier débris. The Tranteine stream does not shift its bed as does the Dordogne, and the moraine matter and transported rocks, resting on the hill in question, are comparatively free from the wear and tear of running waters. For some reason or other it was also evident from the backward vegetation that the Tranteine valley is colder than that of the Dordogne. Professor Lasaulx, of Breslau, in a paper written in the "Ausland" of 1867, directs attention to glacial phenomena near the village of Latour, and I regret that I did not receive the "Ausland" until after our return from Auvergne, for we also went to the Tranteine valley by the long, roundabout route through the village of Latour. On reaching the basaltic platform on the road to Latour, and before reaching the pine woods, I thought it was impossible to account for the presence of some transported masses of trachytic lava which rest on basalt without the aid of ice. We pass by the remarkable basaltic rock known as the Rocher de Vendeix, and come upon a granite district and its deceitful weathering. At Latour are vertical faces of columnar basalt, dykes of which burst through the granite and strew the slopes with their débris. Between Latour and Bousquet M. Lasaulx describes "basaltic prisms polished on the surface by glacial action;" and "erratics resting on rounded and polished granite."

The high road from Latour to Besse crosses the Tranteine valley about 1½ mile from the village of Picherande, and the distance

from thence to the transported blocks is about 5 miles, over an uninteresting route, which is not to be compared for scenery and geological phenomena to that over the Col by the Pic de Sancy. It has, however, the advantage of being much easier in transit. The valley here is a gradual ascent for nearly 5 miles over a poor peaty pasturage with low eminences of granite, overlain by basalt. The country has a *moutonnée* appearance as if a glacier had come over it a long time ago ; and on the slope facing some burons above the road-bridge I detected a boulder of felstone porphyry from the Pic de Sancy. Arrived at the rock masses already described, Sir David Wedderburn made the height of the ridge against which they rest 4,500 ft. above the sea, or 1,509 ft. below the Pic. Mr. Lucy also made full notes on the position of the felstone porphyry and the surrounding geological phenomena. We advise a walk back along the stream to the village of Picherande, as it shows great stranded rock masses on both sides of the stream, especially below the little waterfall near where the erratics are situated. The road to Besse traverses a desolate country, and so backward was the season that, although the 20th May, there was not a leaf on the trees, and the only plant seen was *Petasites albus*. This southern flank of Mont Dore is far colder than the northern side. We passed Vassivière, situated on the bleak hill-side, and where annually a great religious fête is held in honour of Notre Dame de Vassivière, and examined the crater lake, Lac Pavin, which is a most striking scene with its crater-walls clothed with wood and its weird-looking hollow filled with waters dark as Erebus. Besse still retains many of the features of an old mediæval town. Many of the houses are built of stone, and display in the soffits of doors and windows much architectural enrichment of the thirteenth or fourteenth centuries. One house was pointed out as the "Maison de la Reine Marguerite," who, we were told, "mangeait des petits enfans." It bears traces of having been a building of some importance, as there is a broad winding stone staircase in a tower which terminated in a stone vault, on bosses of which are carved figures with the letter M, possibly the initial of Marguerite. Relics of the old town walls still exist, and on an angle of wall is a stone with the following inscription :—

I. BARBVT
I. BESSEIRE
CONSVLS
1010.

We were quartered at the hostelry of "Le Cheval Blanc," and supped off a trout 5 lbs. in weight, from Lac Pavin. The road between Besse and Murol is rough and hilly, but the turf was in some places enamelled with the purple blossoms of *Viola*

tricolor, the parent, probably, of our garden pansies. The little village of Murol is situated on the modern lava current which has flowed from the Puy de Tartaret, while the ruins of the grand feudal castle tower above on the old basalts from Mont Dore. This castle is a most noble and imposing structure still. Its position is grand when viewed from below, while its great mass, its towered outworks, and massive central tower, impress the mind with a sense of solidity and power. It was ransacked and ruined in the revolution of 1793. The views on all sides are very extensive, and most remarkable altogether is this feudal fortress of Murol. The Lake of Chambon is up the valley about a mile, and owes its existence to a dam of lava from the Puy de Tartaret, an extinct volcano with two craters and a cone made up of volcanic cinders. Most astonishing, too, are the accumulations and breccias of the Dent du Marais. Everywhere in this country we are struck with geological phenomena on the grandest scale. First we remark the flow of the old lavas, which form great basaltic platforms high above the present valleys; and yet these basalts and their accompanying breccias must once have flowed in valleys which existed before the erosion of the present watercourses. Again, the recent lava of Tartaret flowed down the existing valley of Chambon when it was excavated as it is now, and this lava has been excavated by the river to great depth. Thirdly, it is quite evident that no glacier has passed down the lower part of the valley since the eruption of the cinder cones of Tartaret and d'Eraignes. Have we any date, then, of the eruption of these cinder cones, for this will assist us in the glacier history? We have. It is recorded by Sir C. Lyell ("Student's Elements," 2nd ed. p. 528), that the lava of Tartaret flowed over the alluvium of an old valley which contains the remains of the Siberian hare (Lagomys), and the fossil horse; and that the arches of a Roman bridge spring from the lava of Tartaret, showing that the ravine near St. Nectaire was in Roman times excavated much as it is now. Remains, too, of the mammoth have, we understand, been found in drifts of the river Couze. So it seems that the northern animals, the mammoth and lagomys, have lived in France since the *outbursts of Tartaret*. Our space will not permit of further allusion to St. Nectaire than to direct attention to its fine old Romanesque church, with an apsidal choir and barbaric representations of men and animals in colour, its cromlech on a hill-side between the upper and lower baths, and the beautiful drive by Champeix to Issoire. The road passes through a picturesque gorge on the river Couze. And here we strike the old granite basement rock through which burst the ancient volcanic masses of the Mont Dore volcano. The lava from Tartaret flows down the valley eroded by an ancient Couze,

and follows the windings of the old river, whose gravels may be seen along its course. Here and there this lava is columnar, and the granite itself appears to be in places traversed by dykes of basalt. The situation of the old town of Champeix is very picturesque, on a commanding eminence at the mouth of the gorge, which is crowned with the massive remains of an old castle. At Nechers the lava from Tartaret stops, having flowed fourteen miles down the river channel. Near Nechers the river has cut through a fine section of the freshwater beds over which the Tartaret lava has flowed in the gorge. Before entering Issoire we arrive at the Montagne de Perrier, with its rock dwellings "Les Grottes de Perrier," which are referred to Roman times. The Mont Perrier tuffs and conglomerates are famous for their rich bone breccias, containing the remains of a great number of animals which appear to have lived in this country in pliocene times. It is difficult to account for these conglomerates, and those of Champeix and Nechers, save that they were carried to their present site by a river which flowed in the same direction as the Couze. From the Mont Perrier conglomerates have been extracted the remains of bears, tigers, hyænas and otters, beavers and hares, associated with mastodons, rhinoceroses, stags, and tapirs, and they lie in gravels and drifts which are interstratified in beds of tuff conglomerate which were laid down at a period long after the miocene volcano of Mont Dore had burst into activity, when the tuffs and lavas it erupted had been borne for miles down valleys, when the old miocene lakes had been turned into dry land, and deep valleys eroded in their silts. Verily this is an astounding country, this Auvergne. It will take years yet to comprehend its geology. Much as has been done by Scrope, Lecoq, and others, there is still far more to do before its dry bones are sorted, its different volcanic outbursts defined, and the strange history they have to tell is revealed. No one has, as yet, an idea of the wonderful physical changes which have occurred during eocene, miocene, pliocene, and post-pliocene ages, which we doubt not will be more or less realised by future geologists. No one has as yet separated the Gannat beds and those of Le Puy en Velay, with their eocene fauna, from the miocene strata crowded with the relics of miocene animals. No one knows under what condition the pliocene animals lived when the Mont Perrier tuffs were accumulating; or what the conditions were when the mammoth and long-haired rhinoceros and marmot lived on the Monts Dome. Still there is some light shed upon all these histories, and if after three visits to the volcanic regions of Central France I may be permitted to give a broad opinion as to the glacial history of Auvergne, I should say that it was long, long ago. When the Alpine glaciers

reached the Jura, and the Rhine glacier swept over the plains of Bavaria, when there were glaciers in the Vosges and in the Black Forest; then I believe glaciers swept across the upper basaltic platforms which are now high above the valleys of Mont Dore. When the great Alpine glaciers passed away, so melted also the glaciers of Mont Dore, and the mammoth and hairy rhinoceros pastured in the vales, with lagomys and spermophilus on the mountains. There may have been short glaciers among the hills, extending only a little way down the valleys, as the transported rocks of Tranteine seem to testify. But the relics of such retiring glaciers are difficult to recognise; and so masked is the evidence of glacial action by the wear and tear of long ages of atmospheric actions, the wash of many streams, and possibly by later volcanic outbursts, that I am convinced much yet remains to be explored before we shall read aright the history of the Glaciers of Auvergne.

EXPLANATION OF PLATE I.

Sketch-map of the volcanic district of the Auvergne.

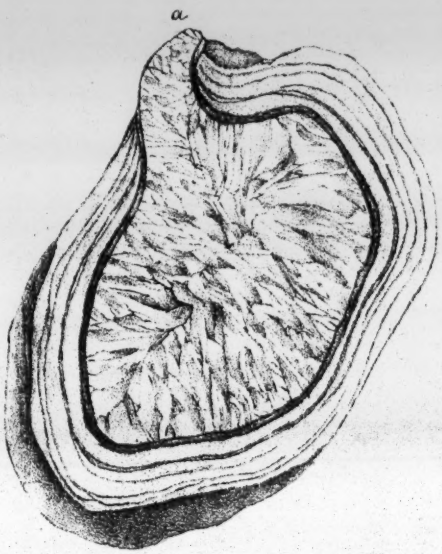

Fig. 1.

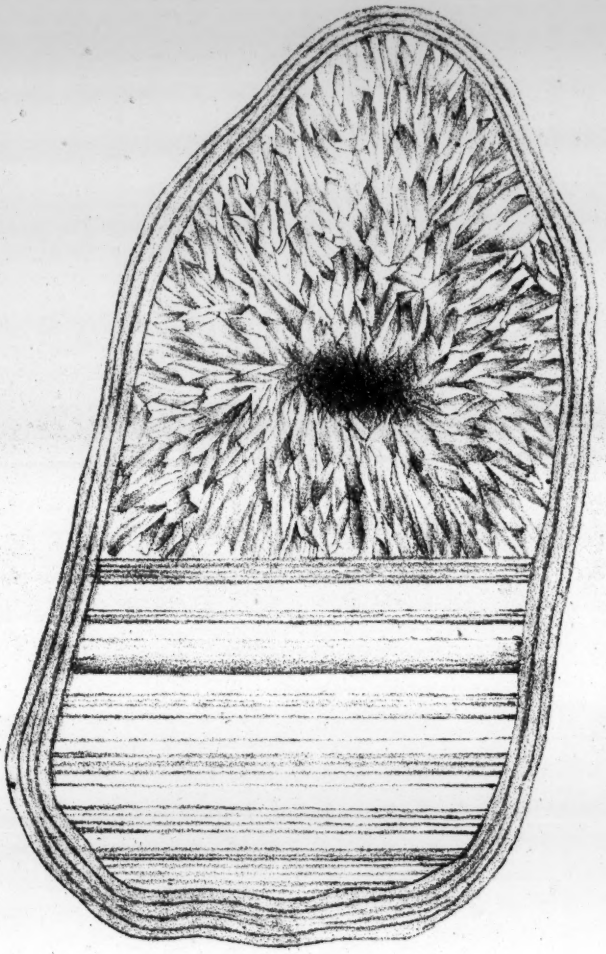

Fig. 2.

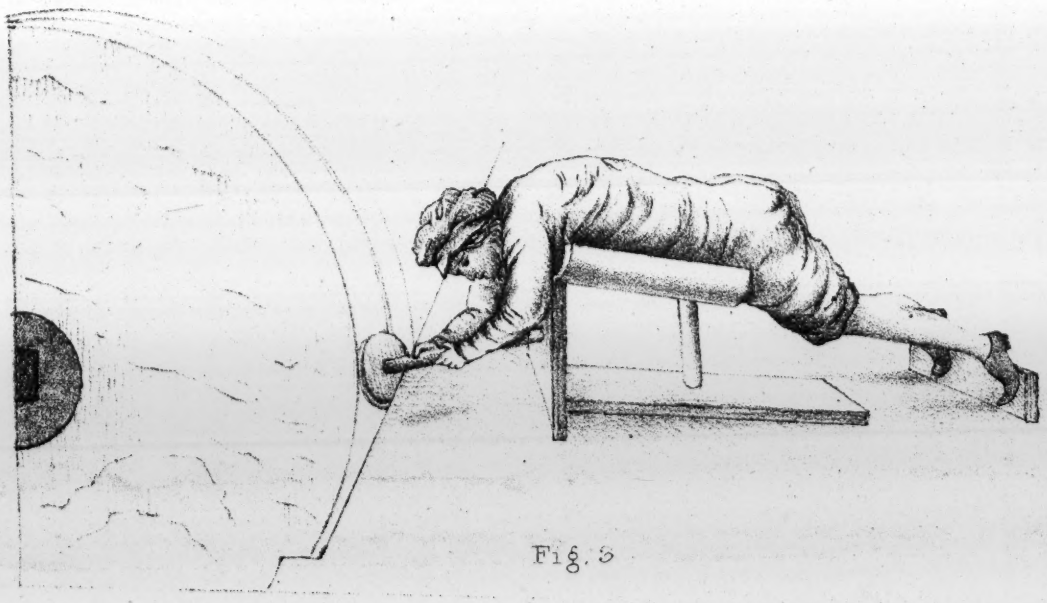

Fig. 3

W. West & Co. lith.

AGATES AND AGATE-WORKER.

AGATES AND AGATE-WORKING.

By F. W. RUDLER, F.G.S.

[PLATE II.]

MOST of our fashionable watering-places offer to the visitor an attractive display of agates and other siliceous stones, worked into a vast variety of ornamental forms. From the abundance of these agates it might fairly be assumed that the rough stones are to be had upon the neighbouring beach for the mere trouble of gathering them. It is true, there are many spots along our coasts where the diligent seeker occasionally finds a pebble which, dull as it may seem on the outside, needs but the touch of the lapidary's wheel to bring to light its

"Chalcedonic beauties, fair and bright."

Such pebbles, however, are as a rule by no means common, even in localities of repute; and it may be safely said that on no part of the English coast could agates be found sufficiently large for the manufacture of paper-knives, bowls, vases, and many other objects commonly exposed for sale. Moreover, these objects are generally offered at so extremely moderate a price that, wherever the raw material may be found, it is clear that it must be cut and polished in some locality where labour is much cheaper than in England. Usually, however, the inquirer considers such difficulties solved when he learns that the stones in question are German agates. Yet this explanation, as we shall presently find, is far from satisfactory. Indeed, we believe that, as a matter of fact, no agates worth naming have for many years been obtained from German soil; and although the old agate-mills are still active they have long been working exclusively on imported stones. We have, therefore, no more right to call such stones "German agates" than we should have to speak of a piece of Carrara marble as "English marble" simply because it happened that it had been worked into form by the chisel of an English sculptor. The true history of these agates, the localities whence they are

obtained, their probable mode of formation, and the methods of cutting and polishing—are the subjects which it will be our business to explain in the present article.

As the tourist ascends the Rhine, and is about to leave one of the most picturesque parts of the river for the broad valley of the Rheingau, he passes, opposite to the vine-clad hill of the Niederwald, the mouth of the River Nahe. This river opens into the Rhine on its left bank, just below Bingen, and a little above the well-known Mouse Tower. The visitor will find the valley of the Nahe almost as beautiful as that of the Moselle, to which it runs nearly parallel, the two valleys being separated by the Devonian rocks of the Hundsrück Hills. Some distance after passing Kreuznach, with its baths, and the neighbouring salt-works, the explorer, following the windings of the river, reaches the picturesquely seated town of Oberstein, about forty miles from Bingen. It is this little town which has been, time out of mind, the great centre of the agate trade of the world. Although situated in the southern part of Rhenish Prussia, Oberstein and the rest of Birkenfeld form an isolated patch belonging to the Grand Duchy of Oldenburg—a kind of political outlier of the far-distant Duchy, entirely distinct from the surrounding Rhine Province.

Few branches of industry owe their birth more directly to the geological structure of the district in which they are seated than the agate-industry of Oberstein. Those hills which rise behind the town in grotesque crags, crowned by the relics of baronial castles, consist of an eruptive rock which German geologists are in the habit of calling melaphyre. It is this rock too which is penetrated by the railway in the neighbourhood of Oberstein, and has thus given rise to the cuttings and tunnels which the visitor passes through, whether he approach the town on the one side from Bingen, along the foot of the Hundsrück, or on the other side from Trèves through the rich coal-field of Saarbrücken. The melaphyre has burst through the sandstones of this coal-field, and comes to the surface in several masses, the largest of which occupies a considerable area around Oberstein, where it is surrounded on all sides by Permian rocks, and is cut through by the river Nahe and its tributary streams.

It would be difficult to find a word in the geologist's vocabulary which has been more abused than Brongniart's name "melaphyre," save perhaps our conveniently ambiguous term "greenstone." A good deal of uncertainty hangs over the original definition, but this has been vastly increased by the different ways in which the term has since been applied. A plagioclastic felspar is the prime constituent; and, according to M. Delesse's analysis, the felspar of the Oberstein melaphyre

appears to be labradorite.* Specimens from the railway-station contain a plagioclase of blood-red colour, due to the presence of lamellæ of ferric oxide.† Microscopic research has shown that in many melaphyres the plagioclase is associated with an orthoclase. Formerly it was supposed that the rock was destitute of olivine, and in this respect differed markedly from basalt; it has, however, been found of late years that olivine is frequently present, and indeed it is difficult to separate some melaphyres, when fresh and unweathered, from true felspar-basalts. Augite, however, is not so constant a constituent of melaphyre as was formerly supposed; in some cases the augite appears to be transformed into a chloritic mineral, and indeed much of the Oberstein rock has a greenish tint. Magnetite is always present, as in so many other eruptive rocks.

Some varieties of melaphyre are compact in texture, others porphyritic, and others again amygdaloidal. All these varieties are to be collected in the neighbourhood of Oberstein, but it is only the last named that is of interest for our present purpose. Just as the carbonic anhydride disengaged during fermentation imparts a cellular character to the dough, which is retained in the bread; so, while the palæozoic lava, which we call melaphyre, was still plastic, bubbles of gas or of steam were disengaged, and have left their impress in the rock, the molten matter having been sufficiently tough to prevent collapse of the walls. Although the normal form of these bubbles would be more or less globular, or probably pear-shaped, with the narrow end downwards, it has generally happened that, during the flow of the lava, the cavities have been drawn out in the direction of the current, so as to form elongated rather flattened cavities, resembling an almond in shape, whence the common name *Amygdaloid* or *Mandelstein*. These vesicles are in some cases empty; but usually they are filled to a greater or less extent with mineral matter, which has been deposited in them by chemical changes occurring in the rock subsequent to its formation. In many amygdaloidal rocks the mineral is merely carbonate of calcium, as may frequently be seen in our well-known Derbyshire "toadstones," which are melaphyres interbedded in the Carboniferous Limestone. But the cavities in the amygdaloidal rocks of Oberstein are for the most part filled with silica in some of its Protean forms. As you pass along cuttings by the road-side you may see the rock charged in some places with myriads of little chalcedonic nodules, or rudimentary agates, which look like so many fossil almonds. Indeed,

* Delesse: "Sur le Porphyre Amygdaloide d'Oberstein" ("Ann. des Mines," [4], xvi. p. 511.)

† Zirkel: "Die mikr. Beschaff. d. Min. u. Gesteine," p. 414.

the notion that the agates of Mount Carmel were petrified melons, was seriously entertained by a writer of only a century and a half ago.* Frequently the siliceous nodules are so abundant that the rock does not look unlike a conglomerate, and some mineralogists have even supposed that the agates are really pebbles and the enclosing rock nothing but the cementing material.†

Although it is almost universally admitted that the vesicular cavities now occupied by the agates have originated in the manner described above, it is only fair to remark that a few Neptunists, unwilling to attribute an igneous origin to basalt and melaphyre, have sought to explain the formation of the cavities by assuming that they represent crystals in a porphyritic rock, which have been removed in solution, thus leaving angular hollows, the walls of which have since been rounded and otherwise modified by various solvents which have gained access to the cavities.‡

To explain the formation of an agate, with its concentric layers of chalcedony, jasper, quartz, and other siliceous minerals, is by no means so easy a matter as may at first sight appear. Not that there is any difficulty in getting the needful supply of silica to form the agate. It may be fairly assumed that some of the component minerals of the agate-bearing rocks will suffer decomposition by meteoric waters holding carbonic acid gas in solution, and that among the products of decomposition free silica will be found. It is notable that the more altered the rock, the finer the agates it contains; thus suggesting some relation between the destruction of the rock and the construction of the agates. We have seen that labradorite is a constant constituent of melaphyre; and this is, of all felspars, the most prone to alteration. Acted on by carbonated waters the silicate of calcium is decomposed, and a carbonate formed, whilst silica is set free. It should be remembered that the siliceous minerals in an agate are often accompanied by carbonate of calcium and by various zeolitic minerals. A large crystal of calcite may frequently be seen seated in the drusy interior of an agate-geode; and it has even been suggested that the so-called "fortification agate" may owe its angularity of outline, as seen in section, to the deposition of silica, either upon or in the place of pre-existing crystals of calcite or of some zeolite.§

* Breye: "Epistola de Melonibus petrefactis Montis Carmel." 1722.

† Volger: "Studien zur Entwickelungsgeschichte der Mineralien," p. 533.

‡ See Bischof: "Lehrbuch d. Chem. u. Phys. Geol." 1866, Bd. iii. p. 620.

§ "On Quartz, Chalcedony, Agate, Flint, Chert, Jasper, and other Forms

But though there may not be much difficulty is tracing the origin of the silica, there are on the contrary extreme difficulties in seeking to interpret some of the appearances presented by agates. Why, for example, should the silica, in one and the same stone, be sometimes deposited in the form of chalcedony, and sometimes shot forth as crystallized quartz; now deeply coloured as bright red jasper, and now delicately tinted as purple amethyst; at one time affecting a crystalline condition, and at another time colloidal? Such alternations in the character of the deposits must have recurred again and again in the history of many banded agates. The successive strata differ considerably in texture, hardness, transparency, colour, and other physical properties; but what has determined these differences? Layer after layer has been spread in equal thickness over all the irregularities of surface, each coat exquisitely thin and delicate; Sir D. Brewster measured the thickness of some of these strata, and found them between $\frac{1}{17220}$ and $\frac{1}{35760}$ of an inch.* How have layers of such extreme tenuity, and yet continuous, been deposited all round the inner walls of an irregularly shaped cavity? These are questions which, simple as they may seem to some at the first blush, will be found to grow in difficulty the more carefully they are studied.

Jakob Nöggerath, the venerable professor at Bonn, who many years ago paid great attention to the study of agates, always maintained that the liquid from which the silica was deposited gained access to the cavities through special openings, or inlets of infiltration.† In some specimens the canal actually remains open, but usually it has become choked by continued deposition of silica. An agate may be so cut by accident that the section passes through this infiltration-channel, as in fig. 1, Pl. II., where the original inlet is seen at *a*. In some specimens several openings of this kind may be detected. Assuming, however, that the solution of silica was thus introduced, it is difficult to see how the deposit could have been regularly thrown down in concentric layers all round the walls of the hollow; no thicker, be it remarked, on the floor of the cavity, than on its roof. It is true we find in certain agates horizontal layers, as though the mineral matter had settled on the floor in obedience to gravity; but then we are perplexed at finding that these flat bands often alternate in the same specimen with regularly concentric deposits, which run with uniform thickness all round the

of Silica geologically considered." By Professor T. Rupert Jones, F.R.S., &c. "Proc. Geol. Assoc." vol. iv., p. 443.

* "Philosophical Magazine," (3), vol. xxii. p. 213.

† Ueber die Achat-Mandeln in den Melaphyren. Haidinger's "Naturwiss. Abhandlungen," vol. iii. part i. pp. 93, 147.

walls, as shown in fig. 2, Pl. II. Bischof suggested that the horizontal bands were formed when the fluid, having been introduced rapidly, was then allowed to rest in the bottom of the cavity; whilst the concentric zones were precipitated from a solution which filtered in slowly, and merely spread over the walls without accumulating on the floor.* To avoid the difficulty of explaining the formation of banded agates by admission of the liquid through special inlets, another hypothesis was advanced by the late Professor Haidinger. According to him the genesis of an agate could be best understood by assuming that, instead of a local infiltration, there had been a general exsudation through the walls of the cavity, so that all parts—the roof not less than the floor—would thus become uniformly coated with silica. The great objection to this explanation lies in the difficulty of understanding how the solution could continue to gain access to the cavity after the first impermeable layer had been deposited. Most mineral substances are porous, and Bischof has cited the case of a compact basalt which when freshly broken was found to contain drops of water in the very heart of the rock. Some of the layers of agate are permeable with great ease, either through distinct pores or between the fibres of which chalcedony commonly consists, as shown under the miscroscope. But it will be presently seen, when referring to the method of staining agates, that whilst some layers are thus freely permeable others appear to be absolutely impervious; and it is difficult to conceive how the agate-forming process could be continued after an impervious lining had once been thrown down upon the walls. To meet this objection, however, it is argued that every agate is sufficiently penetrated by direct fissures to offer means of ingress to the siliceous solution. Whatever views may be held as to the formation of the main mass of the agate, it is generally believed that the first lining of the cavity, in the form of a thin layer of delessite, or ferruginous chlorite, which constitutes the green rind of most agates, is the result of a general percolation and not of local deposition.

As both theories obviously present difficulties, a third mode of origin has been suggested by Dr. Reusch.† If a thin cream of plaster of Paris be introduced into an irregularly-shaped cavity, shaken round, and then poured out, a layer will be left lining the walls of the hollow; by introducing in this way plaster of various colours, successive layers are formed; and, on cutting open the nodule, the appearance presented is strikingly similar to that of a section of a banded agate. Reusch supposes

* "Lehrbuch d. Chem. u. Phys. Geologie," 1866, vol. iii. p. 630.

† Ueber den Agat. Poggendorff's "Annalen," vol. cxxiii. p. 94.

that by the action of intermittent thermal springs the cavities in the amygdaloidal rock have been alternately filled and emptied. The solution carried upwards would certainly be more concentrated, and probably more highly coloured than the descending solution, from which much of the silica had of course been separated during its sojourn in the cavity; hence the differences in the characters of the different layers. Not altogether satisfied with this theory, Herr Lange, of Idar, has suggested some modifications which he conceives will help to account for the regular deposition of thin layers lining the walls of the cavity.* He supposes that after gelatinous silica has been precipitated on the floor of a cavity, an accession of temperature causes the water to boil, and the pressure of the steam then forces the jelly in all directions against the walls of the enclosed space. If the tension of the steam become too great, it forces an exit by piercing the shell; hence what we commonly call inlets of infiltration may after all be exactly the reverse—eruptive, instead of irruptive, canals; channels of egress rather than of ingress.

Both Reusch and Lange argue in favour of the deposition of silica from heated solutions. Great, without doubt, is the solvent action of water at a high temperature, and great the proportion of silica capable of being thus held in solution, as testified by the vast mass of siliceous sinter deposited by the hot springs of Iceland, Colorado, and New Zealand. It has been well established too by the experiments of M. Daubrée,† that certain silicates are readily attacked by water at high temperature and pressure, and suffer decomposition with separation of silica. But, on the other hand, many excellent chemical geologists are satisfied with the feebler power of cold water, and see a sufficient cause of agate-making in the slow but ceaseless action of meteoric waters draining through the rock, decomposing the component silicates, and depositing free silica. Such action must necessarily be slow; so slow, in fact, that, according to Bischof's estimate, the deposition of a layer one line in thickness requires twenty-one years. In order to form one pound of amethyst at least 10,000 lbs. of water must have been introduced into the cavity and evaporated; an action which has been estimated to occupy the vast period of 1,296,000 years.‡ But this represents the formation of only a small stone, whilst in some parts of the world agates of gigantic size have been brought to light. Thus, an agate weighing a centner (110 lbs.)

* "Die Halbedelsteine aus der Familie der Quarze." Von G. Lange, 1868, p. 17.

† "Études sur le Métamorphisme," 1860, p. 89.

‡ "Lehrbuch d. Chem. Geol." vol. iii. p. 636.

was found near Oberstein in 1844. The cavities in which the larger agates occur, were probably formed by the coalescence of several gas bubbles in the original lava.

Whatever agates are found in this country are comparatively small, the finest being the well-known "Scotch pebbles," principally from the Perthshire traps. Larger and finer stones are found in the melaphyre of Oberstein, especially in a hill known as the Galgenberg, or Steinkaulenberg, near Idar, a small town about two miles from Oberstein. As the mother-rock decomposes, the imbedded agates fall out, and these accumulating in the soil attracted attention at a very early date. It was, in fact, this occurrence of agates that led to the systematic quarrying of the melaphyre, and to the planting of agate-mills in the neighbouring valleys. Documentary evidence carries us back four centuries, to A.D. 1454; but how much earlier the Galgenberg agates were worked it is difficult to conjecture.* Only, however, within the last forty years has the industry been fully developed, and this development has unquestionably been due to the large supply of fine stones from South America. In fact, for many years past the agate-quarries of the Galgenberg have not been worked. The writer of this article visited them about ten years ago, under the guidance of an old agate-worker in Idar, but found that they had been long deserted. Adits had been run into the escarpment of the hill, and the softer parts of the melaphyre worked by irregular galleries. Agates, more or less perfect, are scattered in all directions over the floor of the workings, and may be picked out of the walls and roof; but these stones, though pretty enough as specimens, are for the most part scarcely worth cutting, consisting, as they generally do, of a thin rind of chalcedony, lined with a crop of amethyst crystals. A few German agates may, however, be still gathered by the poorer workers, though practically the mines have been abandoned in favour of the South American stones.†

It was in 1827 that some Idar agate workers, who had emigrated to South America with the view of settling in the German colony of St. Leopoldo, observed that the courtyard of a country house was paved with pebbles not unlike the familiar stones of their own hills. Specimens sent home, when cut, polished, and stained, turned out to be beautiful carnelian. The fortunate discoverers collected with ease, from the bed of the Rio Taquarie in Uruguay, several hundredweight of the loose

* "Die Halbedelsteine und die Geschichte der Achat-Industrie," von G. Lange. The writer is much indebted to this work for local and technical details.

† For a description of the quarries as they appeared thirty years ago, see Mr. W. J. Hamilton's paper in "Quart. Journ. Geol. Soc.," vol. iv. p. 209.

stones, and despatched them to Oberstein. From that day to this the South American stones have been constantly imported, and still form the staple material with which the German mills are fed. Numerous other discoveries in Uruguay have been made by emigrants from the agate district of Oberstein, who have devoted themselves to the task of collecting the stones—a task which at the present time is always difficult and often dangerous.

Originally the stones were collected with little trouble, and shipped at little cost; they were found loose in the soil, and brought over simply as ballast. Of late years, however, the trouble and cost have been greatly increased; the agates, becoming scarcer, are found only with difficulty, the owners of the soil demand a rent for the right of search, the Governments of Uruguay and Brazil impose an export duty on the agates, and the shipowners charge for their freight. Large quantities of these so-called "Brazilian stones" are nevertheless still imported, and the impetus given to the agate trade by their discovery half a century ago is not likely to die away.

The agates, having been collected in the interior, are sent down to the coast in waggons drawn by mules or by oxen; they are generally taken to Porto Alegre or to Salto, whence they are despatched to Montevideo and Buenos Ayres in order to be shipped to Europe. Hamburgh, Antwerp, and Havre have at different times been their destination; but at whatever port received they are sent thence by rail to Oberstein. The carnelians, on account of the small size of the pebbles, are packed in cases, but the other stones, unless of exceptional quality, are conveyed in open trucks, like common paving stones. Arrived at Oberstein, they are sorted, and made up in lots, which are exposed for sale by auction in the courtyard of some well-known inn. Advertisements are inserted in the local papers (the *Amts-Blatt für das Fürstenthum Birkenfeld*, or the *Nahethal Bote*), and previous to the sale the agate-workers examine the parcels of stones, chip off fragments, and test them at home with special reference to their capability of receiving colour by processes to be presently explained. The stones, when purchased, are sent to the agate mills, where they are cut and polished on wheels turned by water-power.

In determining the location of the agate industry an abundant supply of water-power was a factor quite as important as the presence of the stones themselves. From the heights of the Hochwald and the Idarwald, in which the Hundsrück culminates, numerous streams roll down with great rapidity, and finally pour themselves into the river Nahe. Of these streams the most important to the agate-worker are the Idarbach and the Fischbach, especially the former. The little Idar is about

1,012 feet above the sea-level at the town of Idar itself, but at Oberstein, where it falls into the Nahe, its height is only 905 feet. In the valley between the two towns, scarce a couple of miles apart, most of the agate-mills are situated. In 1867 there were 153 mills, working 724 stones; and though the greater number of these are in Birkenfeld, some are situated in the adjoining Prussian territory.

Each mill contains from three to five stones, set on a horizontal axle, one extremity of which, passing outside the workshop, communicates with a water-wheel, by which the millstones are set in motion. Most of the older wheels are undershot, but overshot wheels are erected in the modern mills. Each wheel measures from 10 to 18 feet in diameter. As the working is dependent on a due supply of water it formerly happened that the mills were compelled to stand idle during the drought of summer or the frosts of winter; artificial provision is, however, now made for a supply of water during the dry season, and the use of steam has been introduced to a limited extent. When the writer last visited Oberstein, a small engine of 16-horse power was working in the mill of the Gebrüder Purper in Idar; this engine gave motion to five millstones, accommodating ten men, but was capable of turning eight stones, employing sixteen grinders. Another engine was working at Herrstein.

The millstones are made of red sandstone from the Bunter of the neighbourhood of Landstuhl, near Mannheim. Each wheel is about five feet in diameter, and rotates in a vertical plane; the lower half of the wheel moving in a well beneath the floor of the workshop (fig. 3, Pl. II.). The broad edge of the wheel is kept moist by a stream of water constantly trickling down from a launder running above the series of stones. Before being brought into use, the wheels are seasoned by exposure for some time in the open air. Stones fresh from the quarry have been known to suddenly fly to pieces while rapidly rotating; and on two occasions grinders have thus been killed in the Oberstein mills.* The stones generally make three revolutions per second.

When choice stones are to be worked, it is usual to begin by slitting them into shape with steel wheels and diamond powder. The commoner agates, however, are not sawn, but roughly dressed with hammer and chisel, the workman acquiring by long practice great dexterity in striking the stones in the proper direction to insure the desired fracture. The grinding is effected on the broad edge of the red sandstone wheel, which is furrowed with channels corresponding in shape

* Description of the Agate Mills at Oberstein in Germany. "Mechanic's Magazine," 1823, vol. i. p. 199.

with the form which it is desired to give to the object under hand. Sometimes the agate is held simply in the grinder's hand, but usually it is attached to the end of a short stick, and thus applied to the moving wheel. During the rapid rotation of the wheel the siliceous stones are all aglow with a beautiful phosphorescent light, visible even in daylight; and the spectator can hardly bring himself to believe that the carnelians are not red hot. The phenomenon has been studied by Professor Nöggerath.*

One of the most striking, and at first sight painful, features in an agate-mill is the extraordinary position in which the grinders perform their work. Each stone accommodates two men, side by side; but these men, instead of sitting at the wheel, lie stretched in an almost horizontal position, as represented in fig. 3, Pl. II. The workman lies upon a low wooden grinding stool, specially constructed to fit to the chest and abdomen, leaving the limbs free; the hands are engaged in holding and guiding the agate, whilst the feet are firmly pressed against short stakes, or blocks of wood, screwed into the floor; the reaction enabling the grinder to press the agate with much force against the moving millstone. Long experience has shown that in this unnatural position the workman has the greatest command over his work, and the grinding is, in fact, carried on traditionally in the same way as it was certainly done a century ago. Our figure, though copied from a famous work by M. Collini, published in 1776,† fairly represents the agate-grinder as he may be seen to-day at Idar. It might be supposed that the health of the workman would suffer by this constant compression of his chest, but so far from this being the case, the grinders seem to be a strong class of men; they are often to be heard singing cheerfully at their work, and are contented though receiving extremely low wages. It is, in fact, the low value of labour in this rather out-of-the-way district that enables dealers in this country and elsewhere to sell polished agates at excessively low prices.

After having been ground, the agates are polished on cylinders of hard wood or on metal discs, either of lead or of zinc; these are caused to rotate by leather bands connected with the axis of the water-wheel which turns the millstones. Moistened tripoli is employed as the polishing agent. The hollowing-out of vessels, such as bowls; the boring of agate-beads;

* "Philosophical Magazine," (4) vol. xlvii. p. 237.

† "Journal d'un Voyage qui contient différentes Observations Minéralogiques; particulièrement sur les Agates et le Basalte, avec un Détail sur la manière de travailler les Agates." Par M. Collini. The figure is reproduced in Kluge's "Edelsteinkunde," 1860.

and the engraving of cameos, on onyx, are branches of agate-working which are largely practised at Oberstein, but which we have no space here to describe. It remains, however, to notice one of the most interesting departments of the industry.

Beautiful as agates unquestionably are in their natural state, their beauty is, in the judgment of most people, greatly enhanced by the artificial processes of colouring to which the stones are now almost universally subjected by the Oberstein workers. Not that the art of staining is by any means a modern discovery. It was, in fact, known to the ancients, and the matter did not escape the notice of the omnivorous Pliny, though his description is obviously imperfect.* He tells us that the Arabian stones are purified by leaving them for seven days and seven nights in honey. Now the stones might be left in honey till Doomsday without their tint being in any wise improved, and yet not a word is said with respect to any further treatment. If a stone, which has been steeped in honey, be placed in sulphuric acid, the acid entering the pores of the stone decomposes the saccharine matter which has been absorbed, and a deposit of carbon is thus thrown down in a finely divided form in the interstices of the stone, producing a deep black colour. To believe that the ancients stained their agates in this way is to assume that they were acquainted with oil of vitriol; but as it is generally believed that this acid was first obtained by Basil Valentine in the fifteenth century, some writers have suggested that the Roman stone-workers availed themselves of the sulphuric acid naturally exhaled in certain volcanic districts, whilst others again have maintained that the sugar was charred by simple exposure to heat. In whatever manner the ancients effected the colouring, it is certain that the Italian cameo-workers have always been familiar with a process of staining, and these workers were in the habit of visiting Oberstein, from time to time, for the purpose of purchasing the finest onyxes, which they took back to Rome, there to be stained and engraved. The German workers, who sold the uncoloured stones, remained, however, entirely ignorant of the process until the year 1819. It then happened that a native of Idar and one of the Roman stone-engravers got into difficulties in Paris, and were imprisoned together; during their confinement they became communicative, the conversation frequently turned upon agates, in which they had a common interest, and the secret escaped from the loquacious Italian. Shortly afterwards it was conveyed to Oberstein, and, once out, soon became

* See Nöggerath's paper, "Die Kunst Onyxe, Carneole, Chalcedone, und andere verwandte Steine zu färben, zu Erläuterung einer Stelle des Plinius Secundus." ("Neues Jahrbuch," 1847, p. 473.) The passage referred to is in Pliny's "Nat. Hist.," bk. xxxvii. cap. 75.

common property. The art of colouring, so as to produce good onyx from comparatively worthless stone, gave great impetus to the manufacture.

As at present practised, the stones, having been well washed, are usually placed in a syrup of honey and water, or in some cases, in olive-oil. They are then exposed for some time—at least three days, and often longer—to a moderate heat, in a vessel standing in hot ashes or on a German stove, care being taken that the liquid does not boil. When removed they are well washed and placed in sufficient commercial oil of vitriol to cover them, and again exposed to gentle heat. After they have taken colour, they are removed and well washed; and it is often the practice to finally lay them in oil, which improves the lustre. If too strongly stained, the colour may be "drawn" by the action of nitric acid.* The *rationale* of the process of colouring is extremely simple. Certain layers of an agate are found to be porous, whilst others are well-nigh impervious. When, therefore, such an agate is steeped in syrup or in oil, the liquid is absorbed by the porous layers only, and the subsequent treatment with sulphuric acid carbonizes the saccharine or oleaginous matter, and thus produces a deep brown or blackish colour in certain strata, by impregnation with carbon. Some agates never lend themselves to this treatment, and altogether refuse to take colour, whilst others colour in a few hours: the South American stones usually take the colour readily, and hence their great value to the cameo-worker.

It is clear that the essence of this process lies in the differences of texture displayed by the various strata in an agate. Such differences are strikingly seen when a polished section of an agate is exposed to the action of hydrofluoric acid; the different layers are then corroded in different degrees, and a rough surface is obtained, from which Dr. Leydolt has been enabled to print perfect impressions, showing with fidelity every line in the structure of the stone.†

At the same time that the porous layers of an agate are deepened in colour by the process of staining, the intervening non-porous strata appear to be brought out of purer white colour than before. This is probably in many cases the effect of contrast only; but it is known that chalcedony of bluish tint may by the action of heat be converted into a pure white stone. When an agate has been properly stained it usually exhibits alternate bands of strongly-contrasted black and white chalcedony, thus becoming a true *onyx*—a stone greatly prized by the

* "The Science of Gems." By Archibald Billing, M.D., &c. 1867, p. 62. This interesting work contains a view of Oberstein.

† "Denkschriften d. k. Ak. d. Wissenschaften." Vienna. vol. v. p. 107.

cameo-worker, who skilfully engraves a subject in the white layer, which then stands out upon a dark-coloured ground. If the lower stratum, instead of being black, be brown or reddish, the stone is known as a *sardonyx*: large numbers of such stones are cut for setting in rings. The reddish tint of the sardonyx and of the carnelian may be readily developed artificially, and the process of "burning" by which this is effected was indeed known in Germany long before the methods of colouring onyxes were patent. It had often been observed that greyish-coloured agates, after long exposure to sunshine, became reddened, and the effect of artificial heat in developing the colour had likewise been accidentally observed. Experiments were tried in 1813, and since then the stones have been systematically burnt whenever carnelians are required, as has indeed been practised for ages in the East. The German workmen expose the stones for several weeks to the heat of an oven, the temperature being at first very gentle, and then gradually raised. When all moisture has been thus expelled, the stones are moistened with sulphuric acid, and again exposed to heat, the temperature being this time slowly raised to redness. The reddened stone must of course be allowed to cool very gradually.

In 1845 an Idar manufacturer introduced a method of colouring stones bright blue; but this process, unlike those previously described, produces an effect quite unknown among natural stones. Commonly, the agate is steeped first in solution of a ferric salt—a per-salt of iron—and then in ferrocyanide of potassium, or yellow prussiate of potash, whereby a precipitate of Prussian blue is thrown down in the pores of the stone. Other methods are employed, but these will suggest themselves to any chemist; in fact, almost any process yielding a blue precipitate may be applied.

About the year 1855 a green colour was introduced, and chalcedony was thus tinted to resemble the natural chrysophrase. This colour is produced by the use either of chromic acid or of a salt of nickel. Yellow is also a favourite tint among the Oberstein workers, and is commonly obtained by steeping the stones in hydrochloric acid. Of late years various fancy colours have likewise been employed, and even the aniline dyes have been pressed into the lapidary's service. Such tints are, however, fugitive, and are certainly to be eschewed as utterly unnatural, and therefore to most mineralogists little short of repulsive.

It is unnecessary to follow any of the minor branches of the agate industry, but in dismissing the subject let it not be forgotten that it is an industry which, in the neighbourhood of Oberstein and Idar, gives employment to some three thousand hard-working and contented people.

Found originally in the interior of Uruguay; brought first to the coast at much trouble, and then shipped to Europe; conveyed by train to Oberstein, and there sold by auction; cut, ground, polished, and stained by the skilful German lapidaries; and finally distributed through agents to the fairs, watering-places, and chief towns on the Continent, in England, and even in America,—such, in brief, is the history of by far the larger number of agates which at the present day are found in the market. If, knowing this, we are unable to regard them as indigenous products of the locality in which they are sold, surely they are still worth treasuring for their own sake. Beautiful, durable, and marvellously cheap, they are justly popular as ornamental stones; and it is hoped that the effect of this article will be to encourage, certainly not to injure, the branch of industry which they represent. Nor are they less instructive to the scientific student. It is hard to find any polished section of agate which does not offer enigmas as to its genesis that the wisest among us must confess himself unable to fully solve. "Agates, I think," says Professor Ruskin, "confess most of their past history." * But in spite of what has been already deciphered, this history yet remains in most cases to be read. Mr. Ruskin himself has contributed to the "Geological Magazine"† some singularly suggestive papers touching upon the subject, illustrated by tinted plates of agates, full of truth and beauty. By calling attention to the subject afresh, though all too briefly in the present article, the writer trusts that inquiry may be stimulated and interest quickened in the much-misunderstood subject of Agates and Agate-working.

DESCRIPTION OF PLATE.

FIG. 1. Section of Agate, showing inlet of infiltration (*a*), in support of Prof. Nöggerath's hypothesis.

FIG. 2. Section of agate, showing both horizontal and concentric layers, as seen in many stones from Uruguay.

FIG. 3. Agate-grinder of Oberstein at work.

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* "The Ethics of the Dust," p. 190.

† "On Banded and Brecciated Concretions," a series of papers in the "Geol. Mag." for the years 1867 to 1870. Some of these illustrations have been recently reproduced in Mr. Ruskin's "Deucalion," 1876.

CONDITION OF THE LARGER PLANETS.

By RICHARD A. PROCTOR, F.R.A.S.

M. VOGEL'S recent researches into the spectra of the planets are regarded by him as affording evidence unfavourable to the opinion that the planets Jupiter and Saturn are still so intensely hot as to shine in some degree with inherent light. Although it is not at all necessary for the general theory which I have advocated respecting the condition of the larger planets that any portion of their lustre should be regarded as inherent, yet as Vogel's conclusion does bear to some degree on one of the arguments which have been urged in favour of this theory, the opportunity seems convenient for summing up these arguments and discussing briefly the considerations on which M. Vogel bases his objection.

I would remark at the outset that I do not by any means share the opinion of some who, in dealing with this question, and other questions of a like nature, have said that it matters very little what theory is adopted so that it is a convenient working hypothesis, a string, so to speak, on which to thread the observations. It will be found that this method of viewing matters is never expressed except by persons who have fallen into the habit of accumulating observations without reasoning upon them,—in fact, without utilising them. Observation is with them not a means but an end. It seems to me, or rather I may speak more confidently and say that the whole history of science proves, that the real value of observation and experiment lies not in themselves, but in what may be deduced from them. They are the raw material whence scientific knowledge is to be manufactured. It is not the object of a theory to afford a convenient means of classifying observations and also to suggest occasion for making them, but to educe their real significance; and the sole reasonable object of observations is to suggest the true theory and to afford the means of testing and rejecting false ones. To assert that it matters little what theory is suggested so long as it affords a convenient means of classifying observations, is as absurd in reality as it would be to assert that it

matters very little in what manufacture raw materials of a particular kind are employed, so that the manufacture affords a ready means of sorting them away and making room for fresh stores of them. The object of manufacture is to make articles which shall have real value, and raw materials are solely of use in so far as they can be employed in the manufacture of articles of such a nature. In like manner the object of theorizing or reasoning is to discover actual truths, and observations are only useful in so far as they enable us to discover such truths. The mere observer who argues that observation and not reasoning is real science, may be compared to an organ-blower who should argue that his work, not that of the organist, constituted real music. The organist cannot play without wind, the manufacturer cannot get on without raw materials, and in like manner Kepler would never have established his laws without the observations collected by Tycho Brahé, nor would Newton have discovered the law of gravity without the raw material collected by Flamstead; but as it is important in organ music that the wind be exhausted in melody not in mere noise, and important in manufacture that the raw material be employed to make useful not useless articles, so it is and has been a matter of considerable importance whether observations have been idly worked up in false systems like those of Ptolemy or Descartes, or wisely used to ascertain the truth, as by Copernicus, Kepler, or Newton.

The theory which is now to be considered is this, that the planets Jupiter and Saturn are still in a state of intense heat, being at a much earlier stage of planetary development than our earth or those four companion orbs, Mercury, Venus, Mars, and the moon (in one sense more specially a companion than the others) which have been called the terrestrial planets.

At the outset it may be well to consider the evidence for the only other theory which has been advanced on the subject—the theory commonly accepted with apparently as little question as though it had been the result of long and profound investigation, had been tested in every possible way, had been weighed and not found wanting by all the ablest astronomers the world has known. This is the theory that Jupiter and Saturn are bodies in the same condition as our earth.

It is not easy to find any reasoning whatever bearing upon this theory. It would seem almost that so soon as Copernicus had shown that the planets do not travel round the earth as a centre, but the earth with the planets travel around the sun, the conclusion was at once adopted that the earth and the planets are of necessity bodies of the same nature; and that as no one was at the pains to question this doctrine, it became gradually regarded as one that had been established by demon-

strative evidence. The few instances of anything like reasoning which I have been able to find scattered here and there in books of astronomy amount to what follows:—First, because Jupiter and Saturn are planets, and the earth is a planet, therefore those planets are like the earth. (This argument is open to the objection that it begs the question, which is, Whether other planets resemble the earth.) Jupiter and Saturn are globes like the earth (also like the sun and moon). They rotate on their axes, and therefore if they are inhabited worlds like the earth, they have day and night, and in that respect are like the earth. They circle around the sun, and thus if they are worlds like the earth, they are like the earth in having a year; also in having seasons, since their axes are not perpendicular to the planes in which they travel. It would be absurd to suppose that globes so magnificent were made for no special purpose, but we can conceive no special purpose they can subserve except to be the abodes of life; therefore they are worlds like our earth (though the sun, constructed on a still more magnificent scale, is certainly not such a world, or the abode of life). Their moons are manifestly intended to make up to them for their remoteness from the sun (only, when we calculate how much light these moons reflect to their primaries we find that they supply but a small fraction of the amount we receive from our moon). The rings of Saturn were manifestly intended for the benefit of Saturn's inhabitants (though they only reflect light to the summer hemisphere of the planet, and besides turning their darkened side to the other hemisphere, cut off the whole of the sun's light for many months, in some cases for several of our years, in succession). The belts on Jupiter and Saturn may be likened again to our trade wind zones, to which, however, they bear not the remotest resemblance, whether we consider their condition at any given time, or the rapid changes they undergo from time to time. In fine the arguments used by the few writers who have condescended to present even a show of reasoning in favour of the theory that Jupiter and Saturn resemble our earth in condition, amount practically to this—that, assuming all planets to be generally similar, Jupiter and Saturn are like our earth in general respects, in which case they also resemble her in several details.

I do not consider it necessary to discuss Whewell's theory that Jupiter and Saturn are intensely cold planets, because it is professedly based on the theory that they are formed of such terrestrial elements as would, if in the same condition as upon the earth, have the observed density of Jupiter and Saturn, and that these substances, being further removed from the sun, are correspondingly refrigerated. There is not a line of direct reasoning, either *a priori* or *a posteriori*, in Whewell's

chapters on the larger planets—only reasoning which depends on the assumptions which had been made by those whom Whewell proposed to controvert. In fact his theory may be regarded, and was probably regarded by himself, as merely a *reductio ad absurdum* of the unreasoning faith of those who had long held unchallenged the belief in the habitability of all the planets.

I proceed to indicate the leading arguments for the theory that Jupiter and Saturn are still intensely hot, noting first that I do not propose to discuss the details of the various arguments* (which I have already done elsewhere), and secondly that the arguments are not dependent one upon the other, but severally independent, so that if any seem weaker than the rest, the conclusion is not on that account invalidated, but the weight of evidence only *pro tanto* diminished. It is important to notice this, because many who, in examining a series of arguments, recognize, or suppose they recognize, some weakness in the evidence of one or other argument, are apt to infer that the conclusion is to the same degree invalidated as it would be if the arguments were dependent, and therefore each one essential to the establishment of the conclusion.

The first argument for the theory is that derived from the now accepted hypothesis of the growth or development of the solar system. It is rendered to all intents and purposes certain, as well from the evidence of the earth's crust, as from that given by the movements of the sun, planets, asteroids, and satellites, that the solar system was developed from a former nebulous condition. The process of development may have been that conceived by Laplace in his nebular hypothesis, which may be described as the contraction theory, or that recently suggested by meteoric discoveries, which may be called the accretion theory, or, far more probably, the solar system was formed by combined processes of contraction and accretion. But in any case the planets as severally formed were intensely heated, partly vaporous, partly liquid bodies, the larger being the more heated. It is no longer supposed, as in Laplace's time was the case, that the outermost planets were fashioned first. They may have begun to be formed first—this, indeed, is altogether probable—but the vastness of their bulk suggests that they went on gathering in matter and contracting (forming in the process their systems of moons) long after such small planets as Mars or Mercury, though begun much earlier, had gathered in their entire substance. It seems indeed not at all improbable

* I may, perhaps, be permitted to remark here, that the details of many among the arguments here indicated will be found fully discussed in my Lecture delivered at Glasgow on November 9 last, and published by Messrs. Collins, of that city.

that neither Jupiter nor Saturn have quite passed through even the first stage of planetary development, the ring-system of Saturn being suggestive of matter as yet not completely worked-up, so to speak, in that planet's system. But whatever uncertainty rests on this question there is none as to the original intense heat of those larger planets. They must have been far hotter when first formed than was our earth at the corresponding stage of her development. Nor is it at all open to doubt that each stage of cooling would be much longer in the case of these planets than the corresponding stage of our earth's cooling.* Jupiter contains 340 times as much matter as the earth, so that if the two orbs were of the same density Jupiter would have a diameter seven times as great, and a surface about forty-nine times as great, as the earth's. He would radiate, therefore, if at the same temperature, forty-nine times as much heat; but he would have about 340 times as much heat to part with for each degree of cooling; hence his rate of cooling would be slower in the proportion of about 7 to 1. Jupiter appears actually to have a much greater volume than has been here supposed, his diameter exceeding that of the earth nearly eleven times, and his surface exceeding hers about 115 times. This would still leave his rate of cooling slower in the proportion of about three to one. But inasmuch as it is certain that if formed of the same material, Jupiter, when at the same stage of cooling, would be much denser than the earth (because of his greater attractive energy), our assumption rather falls short of the truth than exceeds it. The argument next to be considered will sufficiently indicate this. To complete the present argument it is only necessary to add that the various stages of cooling through which our earth has already passed have certainly required hundreds of millions of years, wherefore the corresponding stages for Jupiter would require *seven* times as many hundreds, and the total period required by Jupiter to

* The argument here used was first advanced by Sir Isaac Newton. "A globe of iron an inch in diameter," he says, "exposed red hot to the open air, will scarcely lose all its heat in an hour's time; but a greater globe would retain its heat longer in the proportion of its diameter, because the surface (in proportion to which it is cooled by the contact of the ambient air) is in that proportion less in respect of the quantity of the included hot matter; and therefore a globe of red hot iron equal to our earth, that is about 40,000,000 feet in diameter, would scarcely cool in an equal number of days, or in about 50,000 years. But I suspect that the duration of heat may, on account of some latent causes, increase in a yet less proportion than that of the diameter; and I should be glad that the true proportions were investigated by experiments." Buffon (according to Bailly) made experiments of the kind, with results confirming Newton's opinion.

reach the earth's present condition of development would exceed the time during which our earth has endured, from her beginning until now, *six* times, even though Jupiter at his beginning were no hotter than the earth. As he was certainly much hotter, it may fairly be said that he would require thousands of millions of years to reach the stage which the earth has reached after hundreds of millions of years; and that, if the two planets were both fashioned at the same time, Jupiter must still require thousands of millions of years before he will have attained to that stage of planetary life through which our earth is now passing. Saturn would not be so far in the rear of our earth because his mass does not exceed hers so greatly. Still he contains nearly a hundred times as much matter, and must be regarded as in all probability, so far as this first argument alone is concerned, hundreds of millions of years behind our earth in point of development.

The second argument is that derived from the small density of Jupiter and Saturn. Jupiter has a volume exceeding the earth's about 1250 times, but a mass only exceeding hers 340 times. Saturn's volume exceeds the earth's 700 times, his mass only 99 times. Jupiter's mean density is therefore about one-fourth, Saturn's about one-seventh, of the earth's. Science no longer accepts the belief that either planet is formed in the main of different materials, spectroscopic analysis having demonstrated the existence of a general uniformity of structure throughout the solar system. Neither can science any longer admit the possibility that Jupiter and Saturn are hollow globes, experiment having proved that under the pressure exerted by the mass of either planet, a substance a hundred times stronger than the strongest steel would be perfectly plastic throughout the greater portion of either planet's interior, so that hollow spaces, if they could be formed for a moment, would fill up just as an open space formed for a moment by thrusting water on one side fills up as the water flows back to its normal position. We are forced then to believe that there is some cause at work to overcome the natural tendency of the planet's mass. Doubtless this cause is the same which operates to prevent the sun's mighty mass from concentrating, as it would, into an intensely dense globe, were its gravitating energies left unresisted—viz., intense heat. The sun is, of course, very much hotter than Jupiter and Saturn; his heat, indeed, overcomes a very much greater contractive energy. But Jupiter and Saturn must be very much hotter than the earth.

The third argument is based on the telescopic evidence of the existence of a very deep cloud-laden atmosphere surrounding each of the planets Jupiter and Saturn.

It is first to be noticed, as respects this argument, that the

general aspect of the belts of Jupiter (Saturn is too far off for similar appearances to be noted) indicates the presence of rounded masses of cloud floating in a deep atmosphere. These rounded masses can only be seen as such on the middle parts of the disc, but there their appearance shows unmistakably that they are really round,—that is, not merely round in appearance, as a circle is round, but round as a globe is round. No one who has studied Jupiter with a powerful telescope can for a moment doubt that some at least among the cloud-masses which are seen in his disc are roughly globular in shape. It is sufficient if only one of these masses has really had such a shape, for though any number of flat objects may float in a sea which so far as they were concerned might be shallow, yet if it is known that a single object has floated in it which was not flat, but on the contrary had great length, and breadth, and thickness, we know that the sea must be a deep one. Some among the rounded clouds of Jupiter, which not only by their shape, but by their shading, indicate a globular figure, would, if actually globular, require an atmosphere five or six thousand miles deep at the very least. The atmosphere may not be so deep as that, or may be very much deeper. Certainly it would at once remove the difficulty last considered if we could suppose the cloud-bearing atmosphere of Jupiter to be thirteen or fourteen thousand miles in depth, for then the solid globe within would not differ very much in mean density from the globe of our earth. But supposing we assume, as the result of the actual telescopic aspect of the cloud-belts, the depth of the atmosphere to be but about 2000 miles, which would be less than the apparently minute diameter of one of the satellites, we should even then find that under the tremendous pressure exerted by Jupiter's attraction the lower strata of such an atmosphere, if composed of any gases known to us, and at the temperature of our own air even in the torrid zones, would be simply compressed into the solid or liquid form. At least they could not continue to obey the laws which perfect gases obey under pressure. Assuming the pressure at the visible limit of the cloud envelope to be less than one-thousandth part of the pressure of our air at the sea-level, then fifteen miles below that limit the pressure would be equal to that of air at our sea-level, fifteen miles lower one thousand times as great, fifteen miles lower one million times as great, and fifteen miles lower yet, or still only sixty miles below the visible limits of the cloud envelope of Jupiter, the pressure would be one thousand million times as great as at our sea-level. The density, if only the gases composing that atmosphere could remain as perfect gases, would be more than a million times greater than the density of water, and thirty or forty thousand times greater than the density of

the heaviest known elements. Of course there is no such pressure, no substance exists at that density, sixty miles below the visible limits of Jupiter's atmosphere, nor ten thousand miles lower yet. No gas could remain as such at ordinary temperatures beneath a pressure which would make it as dense even as water; and if strata could and did exist in Jupiter at the higher pressures and densities named, he would weigh many thousand times as much as he actually does. But we are again forced to the belief that, unless his atmosphere is made of substances altogether different from any with which we are acquainted, there must be some power at work to prevent the compression which would otherwise inevitably result from the tremendous attractive energy of Jupiter's mass. That power can be no other than the fierce heat with which his whole frame, his atmosphere (and all but the exterior strata outside the outermost cloud-layers) are instinct.

It appears to me that a fourth argument of very great force can be derived from the cloud-belts in the atmosphere of Jupiter and his brother giant, Saturn.

The existence of well-defined belts is proof positive of the existence of different rates of rotational motion. For instance, we cannot explain our own trade-wind zones, without taking into account the different velocities due to rotation near the equator and in high latitudes,—matter flowing towards the equator lags behind, matter flowing from it travels in advance, and in either case zones are formed. If a similar explanation could be given of the belts of Saturn and Jupiter doubtless they would be accounted for. But where are we to find the varieties of heat in various latitudes of either planet which could account for the multitudinous belts sometimes seen? or how, if the sun's slow action on these remote and large planets were in question, could we account for the rapid formation and dissipation of cloud-belts? The largeness of these planets is a point of importance to the argument, because the larger a planet the less, *cæteris paribus*, is the variation of temperature for any given difference of latitude measured as a distance in miles. If then we cannot look for the required differences of rotational velocity where we find them in our earth's case, it is clear we must turn to difference of rotational velocity on account of difference of distance from the axis, not at places in different latitudes, but in places at different levels. In other words, we must conceive that under the action of the planet's intense heat vaporous disturbances of the nature of uprush and downrush are continually taking place. Matter rushing upwards from low levels to high levels, where the rate of rotation is very much greater, lags behind, while matter rushing downwards is carried in advance, and thus cloud zones are formed.

A fifth argument is derived from certain considerations depending on the behaviour of sun-raised cloud-masses in our own air, both with regard to the progress of the day, and with regard to the progress of the year. We know that speaking generally the clouds change as the day progresses, and that this is specially the case in those regions of the earth where regular zones exist. The sun, in tropical regions, rises in a clear sky and quickly gathers clouds together; these remain till the afternoon, when they become dissipated (usually with violent disturbance, electrical and otherwise), and the sun sets in a clear sky. As seen from Venus or Mercury the cloud-belt would extend across the middle of the earth's disc, but would not reach to the edge, either on the west or sun-rising side, or on the east or sun-setting side. Nothing of the kind is observable in the cloud-belts of Jupiter. Not only do they extend right across (though becoming fainter near the edges because seen through deeper atmosphere), but cloud masses have been known to remain, quite recognizable in contour, during many Jovian days, and even for forty or fifty of our own much longer days. So also with regard to the year. In Jupiter's case, indeed, the effect of annual changes in the arrangement of clouds would not be recognizable, simply because the planet's equator is nearly coincident with the plane of Jupiter's orbit. But in Saturn's case the inclination of the equator is considerable; so that, as seen from the sun, the equator passes far to the north and far to the south of the centre of the disc, during the summer of the northern and southern hemispheres, respectively. We should expect to find these changes accompanied by corresponding changes in the position of the central zone of clouds. Our terrestrial tropical cloud-zone, being sun-raised, follows the sun, passing north of the equator during our northern summer, until at midsummer it reaches the tropic of Cancer, and passing south of the equator during the southern summer, until at midsummer (December) it reaches the tropic of Capricorn. But instead of the mid-zone of Saturn behaving in this way, it remains always equatorial.

Another (the sixth) argument, and in my opinion an argument altogether irresistible, is derived from the changes which have taken place from time to time in the outline of the planets Jupiter and Saturn, *unless* observations made by most skilful astronomers, and with instruments of considerable power, are to be rejected as unworthy of trust. I refer in particular, first to the observations by Admiral Smyth, Sir R. Maclear, and Professor Peacock, of the reappearance of the second satellite of Jupiter a few minutes after it had apparently made its complete entry upon the planet's disc at the beginning of a transit; and secondly, to the fact that Sir W. and Sir J. Her-

schel, Sir G. Airy, the Bonds and Coolidge in America, and several of the Greenwich observers, have recognized the occasional assumption by Saturn of what is commonly called his "square shouldered" aspect. These observations are far too well-authenticated, and were made by observers far too skilful, to be open to doubt or cavil. They cannot possibly be explained except by assuming that the outlines of Jupiter and Saturn are variable to such an extent that the variations appreciably affect the figure of the planets. Such variations, involving differences of level of two or three thousand miles, are utterly incredible, and in point of fact impossible, in the case of planets like our earth. The heat generated by such changes would of itself suffice to melt and in large degree to vaporize the crust for many thousands of square miles around the scene of upheaval or depression, so that we should thus have, but in another way, the heat which my theory indicates. On the other hand, such changes of outline in a planet whose apparent outline is not formed by its real surface, but by cloud layers thousands of miles above the real surface, are very easily explained. Nay, they are to be expected (though only as rare phenomena). We know that cloud-belts sometimes form, or are dissipated, rapidly on the face of the disc. Equally, therefore, they must sometimes form or become dissipated rapidly at parts of the planet so placed as to form the apparent outline. There would then be a rapid change of outline, such as must have occurred in the case of the apparent reappearance of Jupiter's second satellite. Slower changes in the cloud-belts would correspond to the changes of shape observed in Saturn's case, and would explain Schröter's observation that at times the outline of Jupiter has seemed to him irregular, as if the planet's surface were partially flattened. Other observations tending in the same direction, as peculiarities in the shape of the shadows of Jupiter's satellites on the planet, in the shape of Saturn's shadows on his rings, and so on, are of less weight perhaps than those already considered, but unless those who recorded them (including some of the most skilful observers known) were entirely deceived, such observations can only be fully explained by the great depth of the cloud-laden atmosphere which surrounds the giant planets.

Lastly, there is the argument derivable from the peculiar brightness of the planets Jupiter and Saturn. These planets might be so hot as to glow with an intense light and heat, yet no part of their light might be discernible, the deep cloud-layers simply cutting it off before it reached the outermost or visible cloud surface. Or this might happen with all the rays except those which travelled the shortest way through the cloud-layers. In the former case we should perceive some of the inherent light of these planets, in the latter we should only

perceive their inherent light in the central parts of the disc, which would therefore look brighter than the parts near the edge. This last is the phenomenon actually observed, but it does not of itself suffice to prove (though rendering it highly probable) that the light from the middle portion of the disc is *in part* inherent. Nevertheless the planet's surface might, as I have already said, be intensely hot, and yet no trace of the inherent light be perceptible by us. That, however, could only happen because of the existence of very deep cloud-layers entirely shrouding the glowing planet, and in this case, as the clouds would probably —like our own clouds—have a much higher reflective capacity than rock surfaces have, we should expect to find the planets Jupiter and Saturn shining much more brightly, though only by reflected light, than they would if their surface resembled that of our own earth, or Mars, or Jupiter. Now the following table from Zöllner's "Grundzüge einer allgemeinen Photometrie des Himmels," gives very interesting evidence on this point:—

Snow just fallen reflects about	783	parts of 1000 of incident light;					
White paper	„	„	700	„	„	„	„
Jupiter's surface	„	„	624	„	„	„	„
Saturn's surface	„	„	498	„	„	„	„
Uranus's surface	„	„	640	„	„	„	„
Neptune's surface	„	„	465	„	„	„	„

whereas

White sandstone reflects only about	237	parts of 1000 of incident light;					
Clay marl	„	„	156	„	„	„	
Mars's surface	„	„	267	„	„	„	
The Moon's surface		„	174	„	„	„	

We may take Jupiter and Saturn together, and Mars and the moon; getting average reflective power of giant planets : that of small planets :: 561 : 220; or the giant planets, if they owe their light entirely to reflection, have a reflective power more than $2\frac{1}{2}$ times greater than that of the small bodies, Mars and the moon. As the sea regions of Mars are observably darker than his land regions, it is probable that our earth, if her light could be estimated in the same way (by an observer on Mercury or Venus) would be found to have a smaller average reflective power than Mars, her seas being so much larger.

We are forced by this argument to one of two conclusions—either Jupiter and Saturn shine in part by inherent light, or they are so thoroughly cloud-wrapped as to have a very high reflective power. Either conclusion would agree equally well with the theory I have advocated, though, of course, the former would be much more effective, and would in fact be quite decisive in its favour.

For my own part, I think that the photometric evidence renders it very probable that a slight portion of the light of the planets Jupiter and Saturn is inherent; and I think the colour of the equatorial belt of Jupiter and its changes of colour correspond with this view. I should be disposed to assign, as the reflective power of Jupiter (his *albedo*, as Zöllner calls it) about 500, or more than twice the reflective power of white sandstone, and thus to attribute about one-fifth of Jupiter's light to the planet's inherent lustre. (In Saturn's case Zöllner's observations are much less satisfactory—his measures indeed of the planet's total light were probably even more satisfactory than in Jupiter's case, but it is exceedingly difficult to take properly into account the effect of the ring-system, which, though very much foreshortened when Zöllner made his observations, must nevertheless have appreciably affected his results.) All the known facts accord well with this view.

Certainly the spectroscopic evidence recently obtained by Vogel, or rather the general spectroscopic evidence (for his results are not new) is not opposed, as he seems to imagine, to the theory that the actual surface of Jupiter is intensely hot. His argument is that, because dark lines are seen in the spectrum of Jupiter, which are known to belong to the absorption spectrum of aqueous vapour, the planet's surface cannot be intensely hot. But Jupiter's absorption spectrum belongs to layers of his atmosphere lying far above his surface. We can no more infer—nay, we can far less infer—the actual temperature of Jupiter's surface from the temperature of the layers which produce his absorption spectrum, than a being who approached our earth from without observing the low temperature of the air ten or twelve miles above the sea-level could infer thence the temperature of the earth's surface. There may be, in my opinion there almost certainly *are*, layers of cloud several thousand miles deep between the surface we see and the real surface of the planet. I do not suppose that the inherent light referred to above as probably received from Jupiter, is light coming *directly* from his glowing surface, but the glow of cloud masses high above his surface, and illuminated by it,—perhaps even the glow of cloud-layers lit up by lower cloud-layers which themselves even may not receive the direct light emitted by his real surface.

To sum up, it appears to me, that a theory to which we are led by many effective and some apparently irresistible arguments, and against which no known facts appear to afford any argument of force, should replace the ordinary theory, originated in a haphazard way, and in whose favour no single argument of weight has ever been adduced. Since it appears,—(1) that if the accepted theory of the development of our system is

true, the large planets must of necessity be far younger, that is hotter, than our earth and other small planets; (2) that if made of similar materials, those planets must of necessity be far denser than they actually are, unless they are very much hotter than the earth; (3) that the atmospheres (judging of their depth from the planet's appearance) would be compressed into solid and very dense matter under the planet's attraction unless exceedingly hot throughout their lower layers; (4) that the belts and their changes imply the uprush and downrush of heated masses of vapour through enormous depths of atmosphere; (5) that the cloud-belts neither change with the progress of the day nor of the year in the large planets, but in a manner in no way referrible to the sun, and are therefore presumably raised by the intense heat of the planet's own substance; (6) that so remarkable are the changes taking place in the atmospheres of Jupiter and Saturn, as appreciably (even at our enormous distance) to affect the figure of those planets; and (7) that the planets shine with more than $2\frac{1}{2}$ times the brightness they would have if their visible surface were formed of even so lustrous a substance as white sandstone—I think the conclusion is to all intents and purposes demonstrated that the planets Jupiter and Saturn really are in a state of intense heat. If they ever are to be the abode of life, they will probably not be ready to subserve that purpose for hundreds of millions of years.

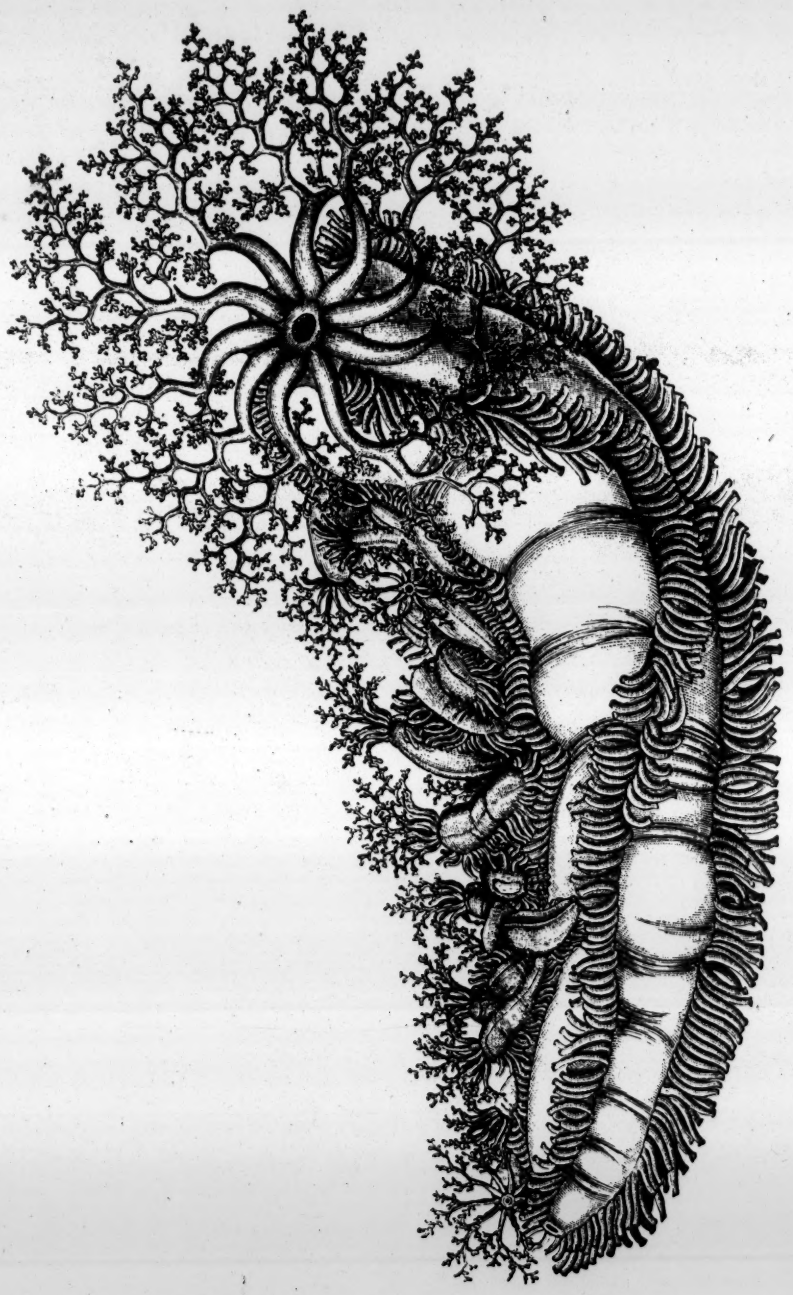
NURSING ECHINODERMS.

AS most of our readers are probably aware, the mode of development general among the Echinodermata is not direct, but complicated by the intervention of what has been called a "pseudembryonic stage"—a minute organism swimming by the aid of cilia, quite distinct in appearance from its parents, and producing the adult form by a process analogous to gemmation. The more striking forms of pseudembryos, when originally discovered, were regarded generally as independent organisms, and their peculiarities of structure led to their being taken as the types of several genera of animalcules, to which the names of *Pluteus*, *Bipinnaria*, *Auricularia*, &c., were given. In some cases, indeed, the young animals could hardly be said to be true pseudembryos in the proper sense of the term, as their structure was merely complicated by certain provisional organs which were cast off when the perfect form was attained; and in some cases the development was found to be absolutely direct, even in species nearly allied to others which had well-marked pseudembryos, just as we find among the Crustacea that the mode of development of nearly related species sometimes differs in the earlier stages.

During the voyage of the *Challenger*, just completed, great numbers of interesting Echinodermata were procured, and among those obtained in the Southern Ocean there were many which not only presented an exception to the ordinary mode of development in their nearest allies, in the fact of the young animals being produced directly, and apparently without the intervention of a pseudembryo, or the formation of any provisional organs, but also exhibited certain curious arrangements of various parts, adapting these to furnish protection to the young during their helpless early stages. In some instances, indeed, the analogy of the arrangements with those prevailing in the pouched mammals of Australia is so strong as to justify the application of the term "marsupial" to these Echinoderms. Sir C. Wyville Thomson has just described in the "Proceedings of the Linnean Society" eight examples of these protective

associations between the mother and the young in the Southern Echinoderms, and as the subject is one of considerable interest and importance we have thought that a summary of his results might not be wholly unacceptable to our readers.

FIG. 1.



Cladodactyla crocea, Lesson. (Natural size).*

* We are indebted to the kindness of the President and Council of the Linnean Society for the use of this and the other illustrations to this article.

In the order of Sea Slugs, or Holothuroidea, Sir C. Wyville Thomson notices two species in which the development appears to be direct; but the arrangements for the shelter of the young are very different in them. One of them, which is identified with the *Cladodactyla crocea* of Lesson, has a curious nursery for its offspring, and not an incubatory pouch. It is a small and elegant species, attaining a length of about 4 inches, and a diameter of $1\frac{1}{5}$ inch; its colour is a bright saffron yellow, and it was found abundantly adhering to the fronds of the gigantic sea-weeds (*Macrocystis*) floating in water from five to ten fathoms deep in Stanley Harbour, East Falkland Island. The oral tentacles, ten in number, are long and delicately branched; and the skin is thin and semitransparent, allowing the muscular bands and other internal parts to be plainly seen. Five ambulacral rows of numerous and well-developed tentacular feet traverse the body from end to end, but not at equal distances apart; three of them are approximated on one surface of the animal and two on the other, the space between the two groups on each side being considerably wider than that between any two ambulacra of the same group. The tentacular feet in the three approximated rows are larger than the others, and constitute, at all events in the female, the regular means of locomotion; in this sex the two other (dorsal) rows subserve a totally different purpose, forming, as it were, the fences of the nursery in which the animal carries about its young. These tentacles are short, and although they are provided with sucking discs, the calcareous framework of the latter is in a rudimentary condition.

It is along these two dorsal rows of tentacles, and indeed adhering to them, that the young animals are carried about by their mothers until they have arrived at a condition to shift for themselves, which must be comparatively late in life. Sir C. Wyville Thomson observed them still occupying this position of dependence when they were nearly half as long as their parents, and he describes the appearance of the mothers "with older families" as peculiarly grotesque—"their bodies entirely hidden by the couple of rows, of a dozen or so each, of yellow vesicles, like ripe yellow plums, ranged along their backs, each surmounted by its expanded crown of oral tentacles." The young animals are nearly perfect miniatures of their parents, except that, as might be expected, the tentacles of the two dorsal rows are quite rudimentary, or barely indicated; the tentacular feet of the other three ambulacra, on the contrary, are very early developed, and it is by their means that the adhesion to the dorsal tentacles of the mother is effected. The placing of the young animals was not observed, but it seems probable that "the eggs are impregnated either in

the ovarial tube or immediately after their extrusion, that the first developmental stages are run through rapidly, and that the young are passed back from the ovarial opening, which is at the side of the mouth, along the dorsal ambulacra, and arranged in their places by the automatic action of the ambulacral tentacles themselves."

A still more curious and interesting example of this direct mode of reproduction, coupled with the presence of a complete incubatory cavity, is furnished by a small Holothuroid which was dredged in February in seventy-five fathoms of water at the entrance of Corinthian Harbour (otherwise called Whiskey Bay) in Heard Island, to which Sir C. Wyville Thomson gives the unenviable distinction of being, so far as he knows, "the most desolate spot on God's Earth." It belongs to the curious genus *Psolus*, of which we have one or two British species, and which is characterized by having the rather short body encased in calcareous scales and plates, with the exception of a soft disc occupying a great part of its lower surface, and bearing three rows of ambulacral tentacles, on which the animal crawls, very much after the fashion of a Gasteropod mollusc. The mouth, with its surrounding ten tentacles, and the vent, open on the upper surface, or at least quite separate from the ambulatory disc.

The species upon which Professor Wyville Thomson's observations were made, measures rather more than an inch and a half in length, and is considered by him to be nearly allied to the northern *Psolus operculatus*, of which he thinks it may possibly turn out to be only a variety. The oral aperture is furnished with a small low pyramid, formed of five closely fitting calcareous plates, which close it accurately when the mouth with its surrounding tentacles is withdrawn within the test (fig. 2); the anal aperture is closed by a similar but less regular valvular apparatus (figs. 2 and 3).

In the female the middle of the back is occupied by a sort of saddle (fig. 2.) composed of large finely granulated calcareous plates of rather irregular form, but fitting together with tolerable accuracy, and from this character the animal has been provisionally named *Psolus ephippifer*. It is here also that we find the peculiarity which renders this species particularly interesting in connexion with the subject at present before us. "On removing one or two of the central plates," says Sir C. Wyville Thomson, "we find that they are not, like the other plates of the perisom, imbedded partially or almost completely in the skin, but that they are raised up on a central column like a mushroom or a card-table, expanding above to the form of the exposed portion of the plate, contracting to a stem or neck, and then expanding again into an irregular foot, which is imbedded in the soft

tissue of the perisom; the consequence of this arrangement is that when the plates are fitted together edge to edge, cloister-like spaces are left between their supporting columns. In these spaces the eggs are hatched, and the eggs or the young in their early stages are exposed by removing the plates (fig. 3)." This therefore is a true special marsupium or incubatory cavity, and as it occupies the greater part of the dorsal surface and its passages advance close to the edge of the mouth where the ovarial aperture is situated, the eggs pass at once into the protective cavities, without any exposure to external dangers. As the young animals increase in size, the surface of the marsupium

FIG. 3.

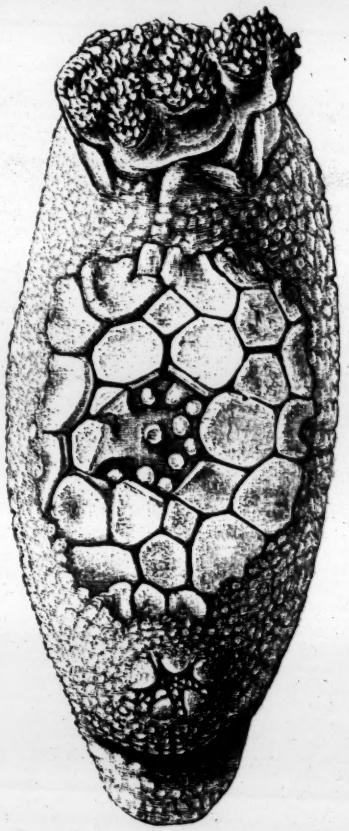
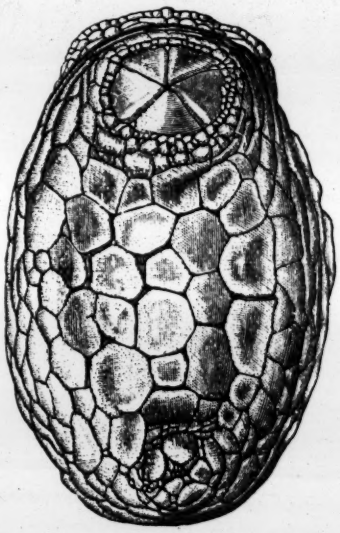


FIG. 2.



Psolus ephippifer, Wyv. Thomson. About three times the natural size.

becomes more and more convex, and the plates enclosing it, which at first fitted accurately together, separate more and more from each other, until at length they are wide enough apart to permit the escape of the young animals. All the young in the same marsupium appear to be nearly of an age. In the male the middle of the back is occupied by a saddle like that of the female, but the plates composing it are not supported upon stalks, and consequently no brood-chamber is produced.

Among the Echinoidea Desmosticha, or Sea Urchins with

ambulacra running from the mouth to the vent, which are placed centrally at the two poles of the test, Professor Wyville Thomson only cites two species, and as these belong to the family Cidaridæ, in which the development, so far as is known, always takes place without the intervention of any so-called "pluteus-stage," the chief interest attaching to these forms consists in the nursing habits of the mother. No example of this kind had previously been observed.

One of the two species in question, a true *Cidaris*, nearly allied to the common *C. papillata* of northern seas, was dredged about the middle of January at depths of from 50 to 70 fathoms in Balfour Bay, a recess near the head of Royal Sound, in Kerguelen's Land. The eggs of this Urchin, after escaping from the apertures in the genital plates at the summit of the test are passed down along the surface of the test towards the mouth, where they are received in a kind of open tent formed by the bending inwards over the mouth of the smaller, slightly spathulate primary spines which are articulated to about the first three rows of tubercles surrounding the peristome. Here the eggs are retained, and the young, which are directly developed from them, are kept under shelter until they have attained a diameter of about $\frac{1}{10}$ inch, when they are entirely covered with calcareous plates, and furnished with spines exceeding in length the diameter of the test. It is true that even before this size is reached some of them are seized with a spirit of wandering, and may be seen "straying away beyond the limits of the 'nursery,' and creeping with the aid of their first five pairs of tentacular feet, out upon the long spines of their mother," but a short excursion seems to satisfy them, and the little truants soon return to the protection of their tent. From its nursing habits Sir Wyville Thomson names this species provisionally *Cidaris nutrix*.

The other nursing Cidarid here described is a species of the genus *Goniocidaris*, which differs from *Cidaris* properly so-called chiefly by the presence of a zigzag impressed line running down the middle of each ambulacral and interambulacral area. The genus includes but few species, mostly confined to the cooler parts of the Southern Ocean, and the one now under consideration, identified by Sir Wyville Thomson with the *Goniocidaris canaliculata* of A. Agassiz, was dredged in January off Cape Pembroke, East Falkland Island, in about 10 fathoms of water. The arrangement for the protection of the eggs and young in this animal is on the same principle as in the *Cidaris* just noticed, but with this difference that the nursery is placed at the opposite pole of the test. The summit of the test exhibits a flat space, including not only the apical plates, but at least the first pair of plates belonging to each interambu-

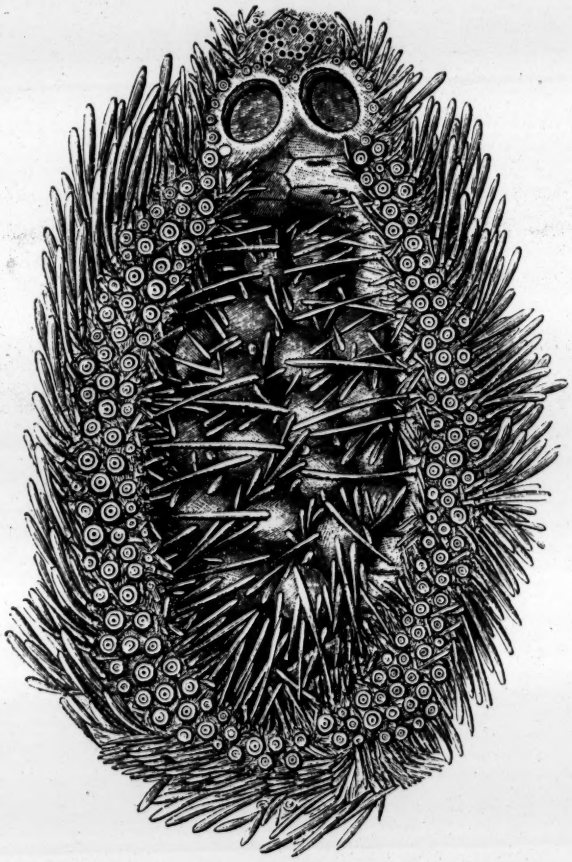
lacrum, and the primary tubercles of the latter bear two sets of spines of much larger size than are usually met with in such a position on the test of allied species, those of the outer circle being, however, considerably larger than those of the inner. These specially developed spines are cylindrical and nearly smooth, those of the rest of the surface being distinctly ribbed, and, during the breeding season at any rate, they are inclined towards the central point of the apex so as to form again a sort of open tent, into which the eggs pass directly from the minute ovarial apertures in the genital plates.

In the only example of the other section of Echinoids the Petalosticha, or forms with petaloid ambulacral areas, which is cited by Professor Thomson, the principle on which the retention and protection of the eggs and young are effected is the same as in the preceding species, but the specialisation of the apparatus is very much greater. The specimens were dredged in January from depths of from 20 to 50 fathoms in Accessible Bay, Kerguelen's Land, and the species is referred to *Hemiaster* of Desor, nearly related to the genus *Brissopsis*, which includes the well known Fiddle-Urchin (*B. lyrifera*) of the northern British seas.

In this species, which Professor Wyville Thomson describes at some length but does not name, the nurseries are four in number, and formed by a widening and depression of the paired ambulacra, which constitute four deep, thin-walled, oval cups, sinking into the cavity of the test. The ovarial apertures are as usual placed opposite the interradial areas, but by the mode of arrangement of the neighbouring spines a sort of covered passage leads from the opening into the marsupium, and along this the eggs pass. The eggs, which are very large, are arranged very regularly on the floor of the incubatory pouch, and each egg is held in its place by two or three short spines which bend over it (fig. 4). The occurrence of numerous specimens of this Urchin, with eggs and young in all stages, facilitated the investigation of the process of development, and proved that this is effected directly. The eggs, when first placed in the pouches, are of a deep orange colour and enclosed within a soft vitelline membrane which they entirely fill. As the blastoderm is formed they become paler, increase in size probably by the imbibition of water, and soon exhibit a whitish spot with a slightly raised border indicating an opening which is presumably the permanent mouth. The surface then acquires a translucent appearance, and becomes strongly tinged with dark purple and greenish pigment, when "almost immediately, and without any definite intermediate steps, the outer wall is filled with calcified tissue, it becomes covered with fine spines and pedicellariæ, a row of tentacular feet come into action round the mouth, the

vent appears at the posterior extremity of the body, and the young assumes nearly the form of the adult." By this time the young animals having acquired a considerable increase of size, their nursery apparently becomes rather small for them and they begin to jostle each other on the floor of the breeding-pouch, and very soon to push each other out between the spines which fringe the pouch. At this period the test of the young Urchin is about $\frac{1}{10}$ inch long, but its intestine is found to be

FIG. 4.



Hemaster, sp. Arrangement of the eggs in one of the marsupial cavities. (Five times the natural size.)

already full of dark sand and to follow nearly the same course that is characteristic of the adult.

In the Asteridea, or true starfishes, an example of the marsupial development of the young has already been recorded by Sars in the case of *Pteraster militaris*, a northern species, in which this process takes place in a brood-chamber formed very much in the same fashion as in the *Psolus* already described, by the stalked paxilli, or calcareous plates of the dorsal surface. Professor Wyville Thomson describes a similar example in a species of *Archaster*, named by him provisionally *A. excavatus*, and allied

to the northern *A. Andromeda*, which was dredged in January from a depth of thirty fathoms off Cape Maclear on the south-east coast of Kerguelen's Land. It is rather a large starfish, attaining a diameter of four or five inches from tip to tip of the arms, and the whole dorsal surface is covered with a pavement-like mosaic of irregularly hexagonal plates. These plates, however, are not directly imbedded in the skin, but supported upon rather slender shafts, so that the whole space covered in by them forms a great series of columned arcades. From the ovarial openings the eggs, when mature, escape into these arcades, and they may be seen in great numbers in the spaces between the shafts of the paxilli, when the arms are bent so as to separate the hexagonal plates of the surface. The discharge of eggs into the brood-chamber appears to be continued for some considerable time, and thus eggs and young in different stages of development are to be found together in the spaces. In the young no traces of the formation of a locomotive pseudembryo could be detected, but it is possible that, as in *Pteraster militaris*, in which the process of development is very similar, some provisional organs may exist at an early period.

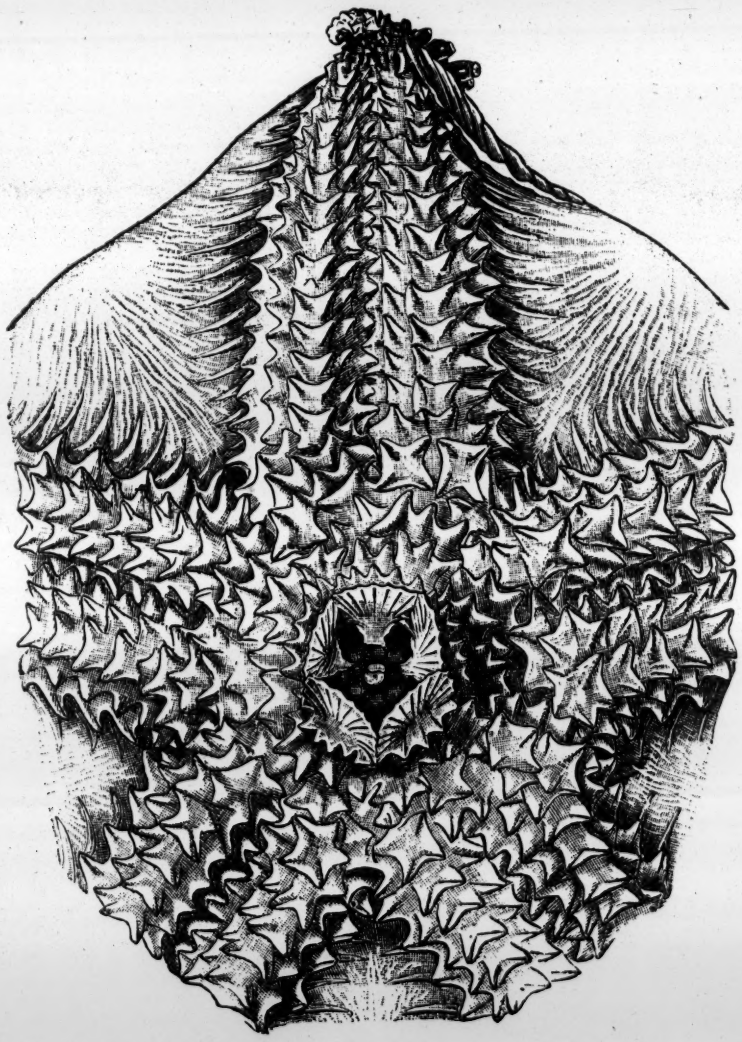
The young animals remain in the brood-chamber until at least six ambulacral suckers are formed on each arm, but when they have attained this degree of maturity they make their way out into the world by pushing through between the hexagonal surface-plates of the paxilli. The first part of the young animal that makes its appearance is always the oral surface, in general the very centre of the body with the mouth; the arms are gradually disengaged afterwards. The young generally make their escape from the nursery between the plates near the re-entering angles between the arms; there they remain for some time clustered, adhering to the surface of their parent in some mysterious manner by the centre of the dorsal surface. Sir Wyville Thomson was unable to ascertain by what means this adhesion is effected, but he says that the attachment is very slight, and that the young animals are removed by the least touch. They remain adherent, however, until they have acquired about twenty tentacular feet in each arm, when they cast themselves upon the world to shift for themselves. It is curious that in the young the madreporiform tubercle exists near the margin of the disc between two of the arms, whilst in the adult it appears to have sunk down beneath the stalked paxilli, and is completely concealed.

Another nursing starfish belongs to the genus *Hymenaster*, established by Professor Thomson some years ago ("Depths of the Sea," p. 120) for a small starfish dredged off the north of Scotland in 500 fathoms of water. The dredging operations of the *Challenger* have shown that this genus is very widely dis-

tributed in the deep waters, its representatives having been met with in all parts of the ocean at depths varying from 400 to 2500 fathoms. The species here described under the name of *Hymenaster nobilis*, was obtained from a depth of 1,800 fathoms, with a bottom of *Globigerina*-ooze at a station 1,099 miles south-west of Cape Otway, in lat. 50° 1′ S., and long. 123° 4′ E. The bottom temperature was only 0.3° C. (=32·4° F).

Hymenaster nobilis is a large species, measuring about a foot in diameter from tip to tip of the arms, the spaces between

Fig. 5.

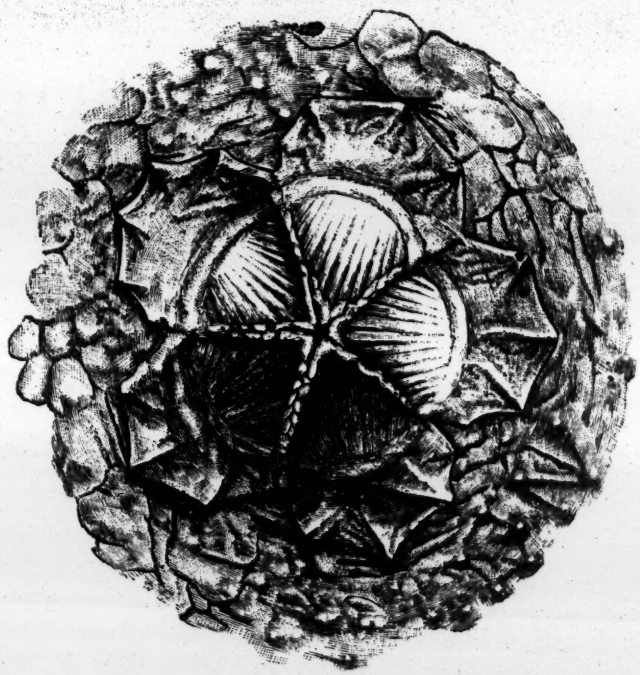


Hymenaster nobilis, Wyv. Thomson. (Half natural size.)

which are entirely filled up by fleshy webs, so that the general form of the body becomes a regular pentagon, very much as in the genus *Pteraster*, to which *Hymenaster* is nearly allied. The whole upper surface of the body and arms is covered with

bundles of from four to six diverging spines about one-eighth of an inch in length, and these support and stretch a strong membrane quite free from the surface of the perisome, having an open space beneath it, like the canvas of a marquee. At the centre of the dorsal surface this membrane terminates at a large aperture, about three-fifths of an inch in diameter, surrounded by a beautiful valvular apparatus which may be best described in Sir Wyville Thomson's own words. He says, "These valves do not essentially differ from the ordinary radiating supports of the marsupial tent; a stout calcareous rod arises from the end of the double chain of ossicles which form the floor of the ambulacral groove. From the outer aspect of this support three or four spines diverge in the ordinary way under the tent-cover; but from its inner aspect six or eight slender spines rise in one plane with a special membrane stretched

Fig. 6.



Hymenaster nobilis, Wyv. Thomson. The marsupial chamber with the valves closed. (Twice the natural size.)

between them. When the valves are raised and the pentagonal chamber beneath them open, these spines separate from one another, and, like the ribs of a fan, spread out the membrane in a crescentic form (fig. 5); and when the valves close, the spines approximate and are drawn downwards, the five valves forming together a very regular, low, five-sided pyramid (fig. 6). Looking down into the chamber when the valves are raised, the

vent is seen on a small projecting papilla in the centre of the floor, and between the supporting ossicles of the valves five dark open arches lead into the spaces opposite the re-entering angles of the arms, which receive the ducts of the ovaries." Although there is no doubt that this remarkable apparatus is destined for the reception of the eggs and the protection of the young during their development, the eggs having been found beneath the membrane in the angles of the arms, and, in a more advanced stage, under the central tent, the phenomena of development could not be studied, such delicate objects being always more or less destroyed when brought up from such great depths as that at which the *Hymenaster* was dredged.

The last species noticed by Sir Wyville Thomson is a brittle star, or Ophiurid, named by him *Ophiocoma didelphys*. It was obtained in January, 1874, at the entrance to Royal Sound and in several of the fjords and bays of Kerguelen's Land. The species is particularly remarkable for the number of its arms, which is normally seven, instead of five, and varies from six to nine.

Most of the adult females of this *Ophiocoma* were found to have groups of young clinging to the upper surface of the disc, the largest being about one-fourth the size of the mother, and the others diminishing in size until the smallest were less than one-sixteenth of an inch across the disc. The largest of the young starfish were always uppermost, and their size decreased downwards, their starting point being the genital clefts on the lower surface of the mother's body. The earlier stages appear to be passed through in the interbrachial parts of the body-cavity, in which, in many specimens, groups of eggs and of young in course of development were found. The examination of these proved that in this species the development of the young from the egg is perfectly direct,—no provisional mouth and no pseudembryonic appendages are found, and the primary aperture of the gastrula persists as the mouth and excretory orifice of the mature form.

Although, as has already been stated, the production of a Pluteus or other pseudembryonic form, or of larvæ with provisional appendages to be afterwards cast off, as a first stage of development is by no means universal among the Echinodermata, it is at least so general as to render the occurrence of these numerous instances of probably direct development in southern forms of the sub-kingdom extremely interesting. And it acquires a special interest from its being coupled with the possession by the adult of special arrangements (brood-cavities and nurseries) for the protection of the young. Of course, although the term "marsupium" has been applied by Sars and other writers to the brood-cavity in which the young Echinoderms are reared, the analogy with the true marsupial pouch of the lower

Mammalia is confined to the protection it affords to the young, which are, as Professor Wyville Thomson says, merely retained in a kind of commensal connexion with the parents until they are in a condition to shift for themselves; the young animals do not appear to be nourished directly from the parent.

As to the reason for the prevalence of such a mode of reproduction among the Echinodermata of the southern seas, often in species whose near allies in other seas show a totally different series of phenomena, it is exceedingly difficult to form even a probable conjecture. The arrangements are evidently protective, but against what? From the remarks made by Sir C. Wyville Thomson he would appear inclined to consider the phenomena to have their *raison d'être* in climatal causes, and yet he says that he is not "in a position to affirm that in these high southern latitudes direct development is universal in the sub-kingdom," and he adds, "I believe, indeed, that it is not so; for species of the genera *Echinus*, *Strongylocentrotus*, and *Amblypneustes* run far south, and a marsupial arrangement seems improbable in any of these." Nevertheless, it is a remarkable fact that during the southern cruise of the *Challenger* between the Cape of Good Hope and Australia only a single form of Echinoderm "pseudembryo" was taken in the towing net, and that was supposed to be the larva of a *Chirodota* from the presence of calcareous wheel-like bodies in its skin.

THE ARCTIC EXPEDITION.

By E. G. RAVENSTEIN, F.R.G.S.

AFTER the return of Sir Edward Belcher's expedition in 1854 the Government of this country appeared to have given up all idea of further prosecuting Arctic discoveries. Other nations, in the meantime, had successfully entered upon this field of research. Swedes and Norwegians enlarged our knowledge of Spitzbergen and of the seas washing the coasts of Novaya Zemlya; Americans pushed their way up Smith Sound as far as the shores of the Polar Sea; the Germans directed their principal efforts to the eastern coast of Greenland, whilst an Austrian expedition attempted the north-west passage, and, failing in its object, discovered an Arctic archipelago to the east of Spitzbergen. All these expeditions were the result of private enterprize, and the successes they achieved were calculated to rouse the emulation of England, which for many years had taken the lead not only in Arctic exploration but also in maritime researches of every kind. Amongst those who most persistently advocated the renewal of Arctic research the late Sherard Osborn holds the foremost place. For ten years he agitated this question, until at length he succeeded in prevailing upon Government to fit out another expedition. During all these years the selection of the most practicable route had formed a fertile source of discussion, but the advocates of that through Smith Sound prevailed in the end, and the leader of the expedition was instructed to take his vessels to an advanced position beyond that Sound, and then to explore the neighbouring coasts, and, above all, to make an effort to reach the North Pole.

Smith Sound had already been the scene of important Arctic enterprizes. Bylot and Baffin, its discoverers, had reached Whale Sound in lat. 77° 30′ N. Captain Inglefield, in 1852 sailed up it to lat. 78° 28′ N. and reported the existence of open water, which he thought might extend as far as Bering Strait and the coasts of Siberia. But Dr. Kane, who hoped to profit by this discovery, barely succeeded in reaching Rensselaer Harbour, where his vessel was frozen in, and whence he effected his retreat,

in boats, to the Danish settlements in the south. Mr. Morton, however, one of his companions, had proceeded with a sledge as far as Cape Constitution, in lat. 80° 35′, and he too reported the existence of open water, and thus incited to further research. The work was taken up by Dr. Hayes, but after a severe struggle against the ice that explorer only reached Port Foulke at the entrance to Smith Sound (lat. 78° 17′), where he wintered. He then proceeded with a dog sledge over the Polar Pack, and travelling at a rate of only two miles a day, reached Cape Lieber in 81° 27′ N., and again reported open water to the north. Far more successful than either of these expeditions was that conducted by Captain Hall, who, between August 23, and Sept. 3, 1871, sailed from lat. 73° 20′ N. to 82° 11′ N., outside Robeson Channel, without being seriously interfered with by ice, but was there stopped by the impenetrable Polar Pack. He wintered in Thank God Harbour, in lat. 81° 38′ N. The subsequent fate of this expedition is well known. Its leader lies buried in Arctic soil; his vessel was beset by the ice, drifted helplessly down Smith Sound, and was finally lost; a portion of its crew passed a second winter in Lifeboat Cove, whilst the remainder drifted southward on a floe of ice until picked up by a passing whaler.

Such were the antecedents of the Smith Sound route when a fresh effort to reach an open Polar Sea by means of it was determined upon. Hall's unique feat of taking his small steamer to a latitude never before attained in any part of the Arctic regions in some measure justified the opinion that a steamer of greater power, even if less favoured by the season, might repeat and even surpass his achievement.

On a bright afternoon in May, 1875, the *Alert* and *Discovery*, the two vessels fitted out for this service, sailed out of Portsmouth Harbour, strengthened to battle with the ice, and liberally provisioned for three years. Having taken on board forty-four Greenland dogs, at Godhavn and Ritenbenk, they parted from their tender, the *Valorous*, on July 17, and stood boldly across Baffin Bay, passing through the dreaded 'Middle Pack' in the unprecedentedly short space of thirty-four hours. On July 28, they were already at Port Foulke, with the entrance of Smith Sound perfectly clear of ice and none floating past to the southward, though the wind, at the time, was blowing fresh from the north. Lifeboat Cove, the scene of the shipwreck of Hall's ill-fated *Polaris* was visited, and the two vessels then crossed to the western shore of Smith Sound. On July 29, when about half-way between capes Isabella and Sabine, the first ice was sighted, and thenceforth the advance to the north proved a constant struggle. Advantage was taken of every opening in

the ice; ramming and blasting were resorted to; and only by audacity, guided by discretion, was it possible slowly to advance. The floes at first were only four feet in thickness, but beyond Cape Frazer old hummocky pieces, twenty feet and more in thickness, had to be encountered. At length, after twenty-five days of this ice navigation, a well-sheltered harbour at the entrance of Lady Franklin Sound was reached, and at once fixed upon as the winter-quarters of the *Discovery*. This was on August 25. Two days afterwards the vessels parted company, and Captain Nares, carefully availing himself of every opportunity that offered, worked his way through the pack. By noon on September 1, he reached 82° 24′ N., the highest latitude ever attained in a vessel, and finally found himself closed in for the winter, on an open coast, in lat. 82° 27′, protected to the seaward by a powerful barrier of gigantic floe-bergs, eighty feet in thickness, aground in twelve fathoms of water.

The autumn sledge-travelling was begun on September 9th, and on the 27th of that month Lieut. Aldrich reached 82° 48′, the highest latitude hitherto attained, and ascending a mountain 2,000 feet in height, was not able to discover land to the north. The sun disappeared on October 12th, only to reappear on March 1st. The winter passed cheerfully, and on the approach of spring officers as well as men were apparently in the finest condition for undergoing the hardships of sledge-travelling. The 3rd of April was fixed upon for the departure of the *Alert's* travelling parties, and on the morning of that day seven sledges with fifty-three officers and men started for the north. On reaching the vicinity of Cape Joseph Henry the sledges separated, some returning to the ship, others proceeding to the north or west. Captain Markham had command of the northern division, whose task it was to proceed over the ice due north in the direction of the Pole. Captain Nares certainly did not expect that this journey would prove a success, as far as reaching a high latitude was concerned, but an effort had to be made. It was by no means certain that the ice, at some distance from the land, would not be found to be in motion, and hence it was necessary that this party should be provided with boats, which had to be carried on the sledges. Captain Markham, with his subordinate, Lieut. Parr, started on the 11th, and in spite of the ruggedness of the ice which necessitated clearing the road with picks and shovels, the intense cold, and the visitation of scurvy, they and their men struggled on until May 12th, when they planted their flags in lat. 83° 20′ 26″, the highest latitude ever attained by this or any other expedition. The progress made good daily only averaged $1\frac{1}{4}$ mile, and never exceeded $2\frac{3}{4}$ miles, and when the party again reached the land, on June 5, only the two officers and six men were able to drag the sledges. It was then Lieut.

Parr started upon his memorable thirty miles march through the snow and returned with the succour so urgently needed, alas! too late to save the life of one of these fearfully tried men.

Meanwhile Lieutenants Aldrich and Giffard had gone west, and on May 17th the former of these officers having traced the coast for 220 miles, reached his furthest in lat. 82° 16′ N., long. 85° 33′ W. His return journey proved a severe struggle, and he reached the ship on June 26th, having been away eighty-four days, during which he travelled 620 miles.

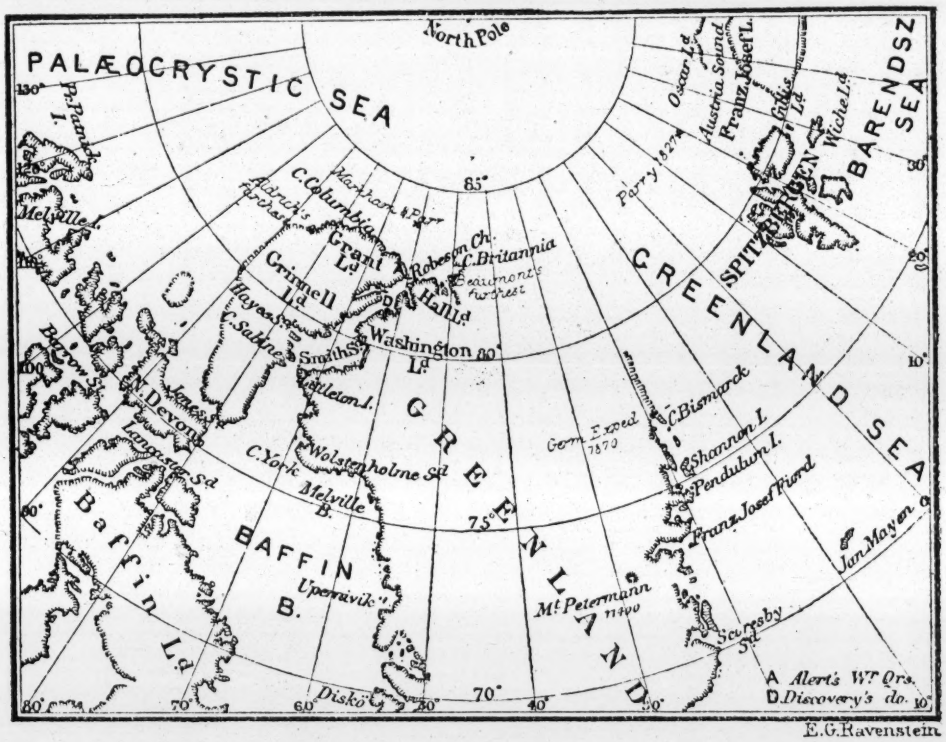
Upon Lieutenant Beaumont, Dr. Coppinger, and Lieutenant Rawson, of the *Discovery*, devolved the task of exploring the coast of Greenland. Their struggles proved equally severe with those of the other parties. On May 21st, Lieutenant Beaumont reached his furthest in lat. 82° 18′ N., long. 50° 40′ W., and saw land far in the north, under lat. 82° 54′. Two men of this eastern division fell victims to scurvy and exhaustion, and its members were only again united on board the "Discovery," on August 14th, having crossed Hall Basin after the ice on both sides of it was already in motion. Lieutenant Archer, in the meanwhile, had explored Lady Franklin Sound, which he found to terminate in a narrow fiord, extending for 50 miles towards the south-west.

Captain Nares wisely determined to return home as soon as the breaking up of the ice should permit his doing so. There appeared to be no chance of taking the ships further north, and at best he would merely be able to extend the exploration of the coasts for an inconsiderable distance, particularly as the health of officers and men had suffered severely. On July 20th, a decided movement of the ice took place; on the 23rd, a strong south-westerly wind drove the pack away from the shore, and on the 31st, having cleared a passage through the protecting barrier of floe-bergs, they entered Robeson Channel. After narrowly escaping destruction from ice pressing upon the ship, she joined the *Discovery* on August 11th. Taking advantage of every opening in the ice, the two ships worked their way slowly towards the south. Cape Frazer was passed on August 25th; open water reached on September 10th, when off Cape Victoria, and it was then possible to make a clear run for Cape Sabine. Captain Nares thus sums up the chances of navigating Smith Sound:—"To the latitude of Polaris or Discovery Bay, if no accident happens to the ship, the passage may probably be made with perseverance most years, by starting early in the season; but it will at all times be a most dangerous one." No vessel, he is confident, will ever round Cape Joseph Henry, or pass beyond Cape Brevoort in navigable water.

The geographical results of this expedition, as far as they find

a place upon our maps, may not, perhaps, realize the expectations of some of the more sanguine advocates of the Smith Sound route, but they are nevertheless of great importance. Not only have the officers of the expedition more carefully delineated some of the discoveries of their predecessors, but they have also laid down about 300 miles of coast which hitherto had not figured upon our maps.

But of far greater importance is their determination of the nature of the Polar Ocean, such as it exists to the north of Smith Sound. The notion of a navigable sea in that portion of the Polar basin has been exploded, and the impracticability of reaching the North Pole by travelling with sledges over the ice



has most conclusively been demonstrated. The sea of which Robeson Channel is one of the most important outlets is evidently of vast extent, and there can be no doubt of its communicating through Bering Strait with the Pacific Ocean. Dr. Bessels, the scientific member of Hall's expedition, already ascertained that the Pacific tidal wave enters Robeson Channel from the north, and meets the Atlantic tide in the vicinity of Cape Frazer. Sir George Nares confirms this fact. Moreover, the driftwood collected by Hall in Polaris Bay has been determined to be of American and Pacific origin, and evidently reached the locality where it was picked up by means of a current passing through Bering Strait, and along the eastern coast of Wrangel Land. This applies more particularly to a

piece of walnut, supposed to have been derived from Japan or the eastern coast of Asia. The valuable collection of driftwood made by members of the late expedition, in all the bays to the north of Robeson Channel opening towards the west, has not yet been examined by a scientific man, but we do not doubt for a moment that it likewise will turn out to be traceable to the north coast of America and to the Pacific, and not to the coast of Siberia. The current which carries driftwood will also carry ice-floes, and thus ocean-currents, the set of the tides, and the predominating westerly and north-westerly winds, noticed by Hall as well as by Sir G. Nares, all combine in accumulating vast masses of ice within the western half of the sea extending from Bering Strait to Robeson Channel, and now appropriately named the "Palæocrystic Sea," or sea of ancient ice. The ice met with to the north of Robeson Channel is evidently as formidable as that known to exist on the western coast of Banks' Land and Prince Patrick Island. Captain Nares describes these ancient floes as being 80 feet in thickness and 1 to 4 miles in diameter. Few, even of the initiated, we are told, can distinguish these floes from icebergs, which they rival and sometimes exceed in size. Where they float into shallow water, they ground in 8 to 12 fathoms, forming a fringe of detached masses of ice rising from 20 to upwards of 60 feet above the sea-level, and affording protection to a vessel between them and the land. But where the coast is steep, they extend close to the beach-line, and if the pressure is strong, as to the east of Robeson Channel, near Cape Stanton, these huge masses are piled up into chaotic confusion. Captain Markham, who travelled over ice of this description, when making his effort to attain a high latitude, tells us that he met only rarely with large floes, having smooth surfaces. As a rule the heavy floes were of moderate size, their surface being uneven and covered with ice-humps, 10 to 20 feet in height, and their edges fringed by hummocks formed from fragments of the previous summer's pack-ice, frozen into a rugged chaotic mass of angular blocks, 40 to 50 feet in height. The snow which covered these floes was scored in ridges, running east and west, in accordance with the prevailing winds, or was heaped up along the foot of the hummocks in deep drifts. The floes were frequently separated by fissures, covered by ice of one year's growth, their general level being about 6 feet above this. On advancing towards the north, the hummocks became larger, and the snow-drifts deeper, until, at the furthest point reached, a perfect labyrinth of squeezed-up hummocks had to be faced.

In the beginning or middle of July the whole pack of ice begins to drive backwards and forwards according to the winds and currents, its main course being towards Robeson Channel, through which it escapes from the polar basin. As the season

advances the pack gradually breaks up into contending masses, small pools of water appearing occasionally. In September the frost sets in again, cementing the broken masses of ice, and by the end of October or beginning of November the pack, which till then had been drifting up and down the channel, begins to settle itself for the winter. No movement whatever has been observed during that season, occasional cracks, caused by tidal currents, alone excepted. A certain qnantity of this ice certainly escapes through Robeson Channel into Smith Sound and Baffin Bay, but compared with the vast extent of the Palæocrystic Sea this quantity is but small, and the evacuation is more than compensated for by the constant western drift of the ice due to winds and currents. The sea to the north of Robeson Channel indeed appears to be hopelessly ice-bound, and the only chance of penetrating the Palæocrystic Sea would appear to be offered by pushing northward along the unexplored coast of Wrangel Land.

Captain Sir G. Nares is of opinion that the Greenland coast does not extend much further north than 82° 55′, and that a portion of the ice of his Palæocrystic Sea finds an outlet to the north of that island and drifts southward along its eastern coast. We would observe, however, that driftwood of Pacific or American origin might be expected to be drifted upon the eastern coast of Greenland if such were the case. The driftwood collected by the German expedition contained Siberian species only, such as are found on the northern and eastern coasts of Spitzbergen, and this proves conclusively that the cold Arctic current passing along that coast carries away the ice formed in the Asiatic half of the Polar basin, and not that formed in the western, American half. Thus much appears to be certain that there are no glaciers in Northern Greenland, or to the north of it, for no icebergs were observed by Sir George Nares. This absence of glaciers is due to the small quantity of snow which falls in these high latitudes, and in their absence the musk ox, lemming, and other animals could easily have migrated from Grinnell Land by a northern road to Eastern Greenland, as suggested by Dr. Brown in an able article published in the "Arctic Papers of the Royal Geographical Society," even if that island should be found to extend far beyond 83° N. Dr. Petermann has hazarded an opinion that the American and Asiatic halves of the Polar basin are separated by land or a chain of islands, extending from Greenland to Wrangel Land. The late Admiral Sherard Osborn likewise assumed the sea, now named the Palæocrystic, to be land-locked, and this theory we believe to be most in accordance with the physical geography of the Arctic regions, as far as it is known to us.

The strictly scientific work of the expedition has not been neglected, for, although the scientific staff was but small, most of the officers had been trained as scientific observers, and they all contributed to the utmost of their power towards enriching the scientific collections. Dr. Coppinger devoted his attention to geology; Captain Feilden, Mr. Chichester Hart, and the Rev. Mr. Pullen studied the natural history of the regions visited; Lieut. Aldrich and Dr. B. Ninnie had charge of the meteorological observations; Captain Markham and Lieuts. Archer, Giffard, and Fulford made magnetic observations; Lieuts. Parr, Conybeare, and May observed with the spectroscope; Lieut. Aldrich with the polariscope; Dr. Moss worked with the microscope; Dr. Colan was engaged in ozone testing and other delicate researches; Lieuts. Beaumont and Rawson made pendulum observations: and Lieuts. Parr and May had charge of the transit instrument. This enumeration of scientific work performed promises a rich harvest of results whenever the numerous observations of these officers shall have been properly worked out. As respects the geological features of the countries explored it was found that Silurian limestones, abounding in fossils, are the most characteristic formation along Smith Sound. Miocene beds, including a thick seam of coal, were found as far north as 81° 44′ N. The greatest cold observed at the *Alert's* winter-quarters was —73·7° F.; the minimum temperature for twenty-four hours was —70·31° F.; and for thirteen consecutive days the thermometer did not rise above —58·9° F. These temperatures appear to be far more severe than those observed by Dr. Bessels in Polaris Bay, where the minimum in January, 1871, only amounted to —58° F. At Wolstenholme Sound, near the southern entrance of Smith Sound, in lat. 76° 30′ N., a minimum of —69·5° F. has been registered, whilst at Yakutsk the thermometer has actually been known to fall to — 76° F.

Westerly and north-westerly winds predominated apparently throughout the year. In autumn there was a heavy fall of snow, but only about six to eight inches fell in the course of winter, and the hill-tops were uncovered by the winds, and remained so until May and the early part of June, when there was another heavy fall. Auroras were observed frequently, but none of the flashes were brilliant, and no connexion between them and magnetic or electric disturbances has been established. Animal life was more abundant and vegetation more luxuriant in the winter-quarters of the *Discovery* than in those of the *Alert*. Musk-oxen, wolves, polar hares, Arctic foxes, and lemmings were found to extend as far as the polar basin. A few ducks, geese, and ptarmigans were shot, but the birds, we are told, do not migrate towards the north or north-west, and it is concluded from this that the ice-bound sea is of considerable idth in these directions.

There can be no doubt that the results of the expedition, as far as we are able to judge from preliminary accounts, must prove highly satisfactory to the geographical world. It is more especially matter for congratulation that the scientific work has not been neglected. A higher latitude might no doubt have been reached had a coast extending northward in the direction of the Pole been discovered, but the attainment of a high latitude should at all times be subordinated to a thorough examination of the land and sea forming the object of exploration.

We do not believe for a moment that England will be content to rest upon the laurels won through this expedition. The Smith Sound route has now been fairly tried, and has been found to be impracticable as one of the gateways leading into the polar basin. There are, however, several other routes offering chances of success, and not one of these has been attempted hitherto by powerful steamers, expressly built for ice-navigation, and manned by a thoroughly competent set of men. One of these routes leads through Bering Strait and along the eastern coast of Wrangel Land into the Palæocrystic Sea. Then there is the route between Spitzbergen and Novaya Zemlya. The *Tegetthoff* was beset there by the ice and drifted about at the mercy of winds and currents until stranded upon the inhospitable shore of Franz Joseph Land, but Norwegian fishermen have frequently passed along it to the eastern extremity of Novaya Zemlya, and Professor Nordenskiöld, than whom none has more experience of these seas, proposes to give it a fair trial next year. A third route, due north from Spitzbergen, enables a vessel to attain a latitude of 81° 30′ or 82° N. almost every year, and, once successful in crossing the ice-stream setting in the direction of Greenland, there opens a fair prospect of making important discoveries. And lastly, there is the route along the east coast of Greenland, whose most persistent advocate is Dr. Petermann. In a letter recently addressed by that geographer to the President of the Royal Geographical Society he points out that the two German expeditions directed to that coast were not equipped as well as a government expedition would have been, and that their comparative want of success need not therefore cause surprise. A well-proved steamer might succeed where the schooner and the little steamer of the Germans were forced to turn back, and Captain Gray, who is thoroughly acquainted with the Greenland sea, feels certain that, once across the ice-stream, open water and undiscovered Arctic islands might be reached. An expedition, such as that of Captain Nares, if it once succeeded in establishing itself on the coast of Greenland, say in 80° N., might really do good work, though Dr. Petermann is oversanguine when he

holds out a hope of "finishing the North Pole in a season," or of "steaming away to the Pole."

Already we hear that in Sweden and the Netherlands they are preparing for an Arctic campaign. Dr. Petermann, too, is again active on behalf of a German venture; the Americans are anxious to "verify" the discoveries of Captain Nares. Is England, not to speak of other maritime countries, to look on, an idle spectator? Might she not, through her example and influence, induce the nations of the world to act on a preconcerted plan in carrying on these Arctic explorations? Five or six expeditions, attacking the North Pole from different directions, and in the same season, stand a better chance of success than the irregular expeditions which have been sent forth hitherto. Their results, too, would prove more useful, and the objects which Lieut. Weyprecht had in view when he proposed to establish physical observatories within the Arctic Circle could partly be attained by them. Will England prove her maritime superiority by taking the lead in this work of Arctic exploration?

REVIEWS.

OSTRICHES.*

VERY considerable interest attaches to the Struthious order of Birds, both from a scientific and an economical point of view. Their remarkable characters, separating them as a group distinct from and morphologically equivalent to all the other existing birds; their curious relations to other classes of vertebrate animals; their singular geographical distribution, and the relations of the living to extinct forms give them great importance in the eyes of the zoologist, whilst the beauty of the plumes produced by at least one of the species, cannot but render it interesting to the fair wearers of such ornaments. The Roman ladies, as we learn from this book, did not adorn themselves with ostrich feathers, which were used, on the contrary, for the decoration of their helmets by a class of men generally supposed to need no such extraneous aids for the captivation of female hearts; but in our days, and in civilized countries, the ladies are generally allowed to have a monopoly of ostrich plumes. That they do their duty pretty thoroughly in the consumption of these articles of luxury is sufficiently clear from the tabular statements here given by M. de Mosenthal, from which it appears that the annual exportation of ostrich feathers from Africa, at present amounts in value to about 603,000*l.*, which probably represents a weight of 120,000 lbs., each pound containing at least 120 feathers.

It may easily be conceived that such a consumption as this gives rise to very considerable slaughter of the birds, and it has long been felt that if the demand for ostrich-feathers should continue to increase as it has done for some years, there will be great difficulty in obtaining an adequate supply. As early as 1859 the Acclimatization Society of Paris, taking these facts into consideration, offered prizes for the successful domestication of the African ostrich in Algeria and Senegal, and in consequence of the attention thus attracted to the matter, several successful attempts have been made both in Africa and in Europe to bring up and breed the ostrich in captivity. But even at a much earlier period it appears to have been the custom among certain native African tribes to keep tame ostriches in enclosures, in order to obtain their feathers easily; and at the Cape a hundred years ago, according

* "Ostriches and Ostrich Farming." By Jules de Mosenthal and James Edmund Harting, F.L.S., F.Z.S. With Illustrations. London: Trübner & Co. 1876.

to Sparmann, many of the farmers "had a number of tame ostriches on their farms, which were allowed to feed at large, and which supplied their owners with plumes, which were made into brooms and helped to drive away the mosquitoes." These early attempts at the domestication of the ostrich were comparatively insignificant. The supply of feathers was chiefly obtained from the wild birds, and, in consequence of their increasing scarcity in easily accessible localities, the price of the commodity became very high. Towards the year 1870, however, the attention of South African farmers was directed to the advantages of keeping ostriches as domestic birds; and it is to the increasing adoption of this practice that we must ascribe the enormous increase that has taken place since 1870 in the quantity of feathers exported from that part of the world. In 1865, it appears there were only 80 tame birds in the Cape Colony, whilst in 1875 the census returns showed the existence of no fewer than 32,247. The feathers obtained from the tame birds are stiffer and less valuable than "wild feathers," but nevertheless this new industry must be a most productive one, if we may judge from the experience of Mr. W. Kinnear, of Beaufort West, who in 1870 had twenty-nine ostriches on eight acres of garden-ground, fourteen being in immature plumage. "For three pluckings of fifteen of them, at intervals of eight months, he received the sum of 240*l.*, which is at the rate of 120*l.* a year, or 8*l.* per bird." It must be remarked that in 1870 the price of the feathers was unusually low, and that the space occupied by these twenty-nine birds was estimated to be sufficient for three times the number.

We have devoted so much space to the commercial side of the subject partly because it may interest many of our readers to know the extent and importance of the trade in ostrich feathers, but mainly because it is to the curiosity excited by the display of a large collection of feathers at the Vienna Exhibition of 1873 that we are indebted for the admirable work on the Ostriches by MM. de Mosenthal and Harting. The practical part of the subject is treated by the former gentleman, who describes the earlier attempts at the domestication of the ostrich, notices the endeavours that have been made to introduce ostrich-farming into other colonies, especially in Australia; gives full details as to the progress of the industry in Africa, where it has even advanced so far as the adoption of incubators, and "artificial mothers" for hatching and rearing the young; and furnishes most interesting particulars connected with the trade in ostrich feathers. As a contribution to economical zoology, Mr. de Mosenthal's share of this book is most interesting and valuable.

We think it was Sir Richard Steele who, in speaking of his starting the "Spectator," and calling in the assistance of his friend Addison, described himself as being in the position of some small prince who had been aided by a big one, and found himself in the end of little consideration by the side of his ally. We fancy that Mr. de Mosenthal might say something of the same kind. Reading between the lines of the preface, it seems pretty clear that that gentleman, who, as Commissioner for the South African Colonies, exhibited the collection of ostrich-feathers at Vienna, having determined on publishing a short account of the new industry, thought it desirable to prefix to his treatise an account of the natural history of the ostrich, and

called in to his aid the genial pen of Mr. J. E. Harting, whose varied powers and great ornithological knowledge eminently fitted him for the task; and that the few introductory notes on the natural history of the ostrich have grown into a sort of monograph of all the species of Struthious birds, occupying just three-fourths of the book, which, as the authors tell us, has grown by a "process of evolution from a pamphlet into a volume." We fancy that few who are interested in natural history studies will be inclined to quarrel with the authors on this account. It is no small advantage to have a good, readable, and reliable natural history of so interesting a group as the Struthious birds, and this is what Mr. Harting has presented to us. He describes all the species of the group—the African Ostrich, the South American Rheas, the Emus of Australia, and the Cassowaries of Australia and the islands of the Australian region; and gives a short account of the curious Kiwis (*Apteryx*) of New Zealand, which are also referred to the Ratitæ. The natural history of each species is given so far as it is known; and in search of information on this subject, the works of a great number of naturalists and travellers have been ransacked, with the most interesting results. In connection with this, however, we cannot but think that the long extract from M. Vavaseur's account of the Rhea ought hardly to have been given in its original French. The little volume is illustrated with good woodcuts of some of the species described, and of the characteristic parts of others, and a few hunting scenes are introduced.

NORTH AMERICAN MOTHS.*

THE American Geological Surveys by no means confine their activity to what might seem at the first glance to be their legitimate sphere. The actual officers of the survey are expected to have an eye for the picturesque in the scenery of the out-of-the-way places that their labours necessarily lead them to visit, and to notice any facts of interest in other departments of science than their own, and in general naturalists are attached to the parties sent out, in addition to the regular staff of the survey, for the purpose of investigating the zoology and botany of the regions traversed. In this way a great amount of information upon the general natural history of the vast territories of the United States is rapidly being accumulated, and the authorities publish the results of the investigations thus made in by no means a niggardly fashion. Several of the States have already published valuable treatises on the zoology of their districts, and in addition to many papers of interest on zoological subjects which have appeared in its bulletin, the Geological Survey of the Territories some years since published a monograph of the Acrididæ of the United States by Mr. Cyrus Thomas. Entomologists are now indebted to Dr. Hayden for another valuable work on insects in the "Monograph of the Phalænid Moths" of the United States

* "Report of the United States Geological Survey of the Territories," Vol. X. "A Monograph of the Geometrid Moths or Phalænidæ of the United States." By A. S. Packard, Jun., M.D. Washington. 1876.

by Dr. Packard which has recently appeared. It is a most important contribution to entomological literature and at the same time is precisely one of those works which could never have been so well produced by private enterprise.

The geometrid moths, the *phalænæ geometræ* of Linnæus, have received their name, as is well known to entomologists, from the peculiar mode of progression of their caterpillars, which is a necessary consequence of their usual conformation. These curious larvæ generally have only two pairs of fleshy prolegs situated close to the hinder extremity of the body, and in walking most of them adhere to their support alternately by these and the six true legs which are on the first three body segments, and thus move by a series of steps in which the body is alternately stretched to its full extent, and bent into a loop. Hence these larvæ are often called loopers, a name which, among collectors, is sometimes applied to the moths. Another result of the arrangement of the prolegs so far back on the body, is that many of these larvæ are able to mimic the twigs of the tree on which they feed in the most perfect manner; clinging with the hind feet they extend their bodies stiffly and thus present exactly the appearance of a bare twig.

The moths produced from these curious caterpillars are often of great beauty, although many of them display sober brown tints, more or less variegated. Others, although of sober colours, are adorned by having these arranged in most elegant patterns. But the striking species are not very numerous, and in general the Phalænidæ share the common lot of moths, in being rather difficult to determine specifically. Staudinger and Wocke's catalogue gives about 800 species of Phalænidæ as inhabitants of Europe, and although in the present work Dr. Packard does not describe half this number, those who have ever laboured at the discrimination and determination of species of moths will know that he must have undergone very considerable labour in preparing his monograph.

But whatever labour it may have cost him he may certainly congratulate himself on having produced a work which will be received with gratitude by all students of American Lepidoptera both at home and abroad. All the known species and varieties are described in detail, both the generic and specific synonymy is given in full and with dates, a most important matter in a work of this description, and all the species are figured. To make his treatise more complete, Dr. Packard has also quoted under the title "Desiderata," the original descriptions of the species which he has been unable to see, thus enabling any entomologist who may meet with one of them to determine the nature of his prize. In defining his genera Dr. Packard has availed himself largely of the characters derived from the venation of the wings, which have long been regarded as of great importance in the study of the Hymenoptera and Diptera, but have only of late years been much employed among Lepidoptera. Unfortunately the use of such characters is liable to be pushed too far, and even in the present excellent work we recognise the tendency to excessive generic division which is the great vice of systematic zoologists of the present day. However, Dr. Packard has certainly done his best to render matters as plain as possible, for he furnishes the student with six plates containing figures of the venation of the wings of all his genera. Besides, there is a plate of outlines of

various anatomical details, and six plates crowded with figures of the moths themselves, which, although not coloured are very nicely drawn and characteristic.

SCIENCE MANUALS.*

FOLLOWING the example of some other publishers Messrs. Chambers have commenced a series of "Elementary Science Manuals" intended to serve the two purposes of self-instruction and school-teaching. The manuals already published include Geology and Historical Geology, by Mr. James Gikie; Astronomy by Dr. Findlater, who is the general editor of the series; Electricity by Mr. John Cook; Chemistry by Dr. Crum Brown; Language by Dr. Findlater; and Mythology by Mr. A. S. Murray, of the British Museum. The names of these authors are of themselves a sufficient guarantee that the work is creditably done, and an inspection of the text shows that they have really succeeded in compressing into these very small volumes an astonishing amount of good and well-selected information. It seems to us, however, that some of them are rather sanguine if they expect the scholar after studying the manuals to answer some of the examination questions that they have appended to them.

PAGE'S GEOLOGICAL TEXT-BOOK.†

DR. PAGE'S "Advanced Text-Book of Geology" is so well known that we need do little more than announce the appearance of its sixth edition. Naturally there is little or no change in the general treatment of the subject, but the author appears to have carefully worked in the results of recent investigations, where these come within the scope of his work, and he has introduced a considerable amount of additional information without materially increasing the size of the book, by placing the new matter in small type. Several new illustrations have been inserted.

NORTH AMERICAN VERTEBRATA.‡

THIS little book is a synopsis of the vertebrata of the northern parts of the United States, and it ought to prove an exceedingly useful manual for residents and travellers in the region of the zoology of which it treats.

* "Chambers' Elementary Science Manuals." Edinburgh. 1875-76.

† "Advanced Text-book of Geology, Descriptive and Industrial." By David Page, LL.D., F.G.S. Sixth edition, revised and enlarged. Edinburgh and London: W. Blackwood and Sons. 1876.

‡ "Manual of the Vertebrates of the Northern United States, including the district east of the Mississippi River and north of North Carolina and Tennessee, exclusive of Marine Species." By David Starr Jordan, M.S., M.D. Chicago: Jansen, McClure and Co. 1876.

The author has evidently compiled it with great care, and the determination of the species will be immensely facilitated by the elaborate tabular arrangements which serve as a guide to the genera. The whole of these tables are to a greater or less extent artificial in their character, but they profess to be nothing more, and in some of the larger and more complex groups this very artificiality has been taken advantage of to render the tables more direct guides to the desired end than they could have been if it had been attempted to make them serve as an indication of the natural relations of the forms. Thus, when the characters of the genera are subject to some slight variation, the characters of the aberrant species are worked out separately, so that the same generic name may occur two or three times in the same table, and by this means there is no doubt the species of the genus may be got at more readily. Under the head of fishes, of course, only the forms met with in fresh water are noticed, but the reader will be astonished at the immense number and variety of the animals of this class that find a home in the great lakes and rivers of the North American Continent. The fishes, indeed, appear to be Dr. Jordan's speciality, but it is to be regretted that he has thought it necessary to adopt so many genera. Of natural history, of course, there is very little in the book, which only professes to be a synopsis. The American geographical distirbution of the species is generally given, and in some cases where an animal is common to both sides of the Atlantic, its occurrence in Europe is noted, but very frequently this piece of information is omitted even in the case of species of the same genus. This is a defect which we hope may soon be amended in a second edition.

AMERICAN GEOLOGICAL SURVEYS.*

THE energy and activity displayed by the Government geological surveyors in the United States are certainly worthy of all praise, and they are supplemented by a liberality on the part of both the central and local governments which contrasts rather strongly with what we are accustomed to nearer home. The important volumes on the "Cretaceous and Tertiary Fossil Vertebrata of the Western Territories," by Professors Leidy and Cope, and on the Cretaceous Flora of the same region, by Professor Leo Lesquereux, are now followed by a most admirable "Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country," which, while it cannot fail to interest the palæontologist by the numerous excellent descriptions and figures of fossils, and the discussion of their generic and specific relations that it contains, must prove of almost equal importance to the geologist on account of the precise definition of the divisions and subdivisions of the deposits from which the fossils described have been obtained and the light thrown on their relations to each other and to deposits in other parts of the world.

The fossils here described are the result of the collections made by the

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* "Report of the United States Geological Survey of the Territories," vol. ix. "A Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country." By F. B. Meek. Washington, 1876.

officers of the survey under the direction of its chief, Dr. Hayden, who himself commenced these laborious investigations more than twenty years ago. The descriptions of cretaceous fossils alone occupy 508 pages, in which about 240 species or distinct varietal forms are described, mostly mollusca; 63 distinct forms are described from the "Brackish-water and Lignite Beds," 2 from the "Wind River Tertiary," and 7 from the "White River Tertiaries." These indications of numbers, however, give no sort of indication of the amount of valuable palæontological information contained in this volume; they represent a certain number of species of more or less interest to the student of fossils; but the remarks upon them, and especially upon the genera and their subdivisions are of the greatest importance to palæontologists everywhere.

In his "Introductory Remarks" on the geology of the locality from which his fossils were derived, Professor Meek gives elaborate comparative tables of the various sections exposed, showing the equivalence of the beds in the different localities. The lowest cretaceous deposits everywhere rest upon palæozoic and generally carboniferous rocks, and in all the sections here given are regarded as the equivalents of the Dakota group in the Nebraska section, generally containing, like the latter, numerous plant-remains. Above this group come in the Nebraska section, the Fort Benton group, and the Niobrara group, the whole attaining a thickness of about 1,400 feet in the typical locality, and forming the lower cretaceous series, equivalent to our Gray Chalk and Upper Greensand (Turonian and Cenomanian of D'Orbigny). Above these the upper series consists of two groups, the line of demarcation between which does not appear to be very strongly marked,—the Fort Pierre group with a thickness of 700 feet, and the Fox Hills group 500 feet thick. These are regarded as the equivalents of the upper chalk and Maestricht beds (Senonian, D'Orbigny). In Alabama and Mississippi, and everywhere east of the Mississippi river, the second and third, or Fort Benton and Niobrara groups appear to be absent, as also in the New Jersey section, which has served Professor Meek as a term of comparison between the American and European cretaceous series; and in New Mexico the cretaceous deposits, according to Dr. Newberry, fall into three great divisions, the lowest of which is regarded as equivalent to the Dakota group, the middle one to the two upper members of the lower series, and the uppermost to the whole of Professor Meek's upper series.

With regard to the true position of the Dakota group and its equivalents in other localities, which are so remarkable on account of the leaves of highly-organised dicotyledonous plants found in them, there seems still to be room for difference of opinion, and Professor Meek himself says, "The evidence respecting the exact part of the European cretaceous series to which the Dakota group belongs is not entirely satisfactory, the few animal remains yet known from it being mainly casts, and, so far as determined, not such forms as can be regarded as especially characteristic of any particular horizon in the cretaceous of Europe. Up to this time we also know of no single species being common to it and any of the beds alone; but then we, as yet, know comparatively only a few species of animal remains from this rock. One of these, however," he adds, "belongs to the cretaceous genus *Leptosolen*; while the other shells are allied to cretaceous species, and

unlike jurassic forms. In addition to this, the modern affinities of the numerous leaves of the higher types of dicotyledonous trees found in it, present a strong objection to the adoption of the conclusion that it may belong to a lower horizon than the Upper Greensand of British geologists, while its position directly below beds almost beyond doubt representing the Lower or Gray Chalk, precludes its reference to any higher stratigraphical position." Professor Meek consequently regards the Dakota group as the American equivalent in whole or in part of the European Upper Greensand.

Overlying the Fox Hills group, the highest of the undoubted cretaceous series, come what the author calls the "Fresh and Brackish-water Lignite Deposits," a series of sands and clays, with interspersed beds of impure lignite. These deposits are divided into two groups—the Judith River and Fort Union groups. The latter, which is regarded as the more recent of the two, is also much more widely spread than the other over the Missouri region. The chief interest attaching to these deposits, however, and especially to the older, or Judith River group, is to be found in the singular assemblage of fossil remains which they contain. This seems to mark them out as passage beds between the Cretaceous and Tertiary series. Thus the vertebrate remains found in them seem to point directly to Cretaceous affinities some of them being Dinosaurians related to *Iguanodon*, *Megalosaurus*, &c.; whilst associated with these are others, such as a tortoise belonging to an Eocene genus, and garfishes of the genus *Clastes*, which, with the remains of plants also found in the deposits, would seem to indicate an Eocene Tertiary date. Similar, if not identical, deposits are recorded as occurring in various parts of the country, and especially in Southern Wyoming, where a lignitiferous group, called by the author the Bitter Creek series, exhibits in a very striking manner the intermixture of Cretaceous and Eocene types above referred to, but with this remarkable addition, that some species of shells obtained from low down in the series exhibit striking Cretaceous affinities, whilst others from a higher horizon appear to belong to decidedly Eocene types. On the whole, it would appear that in the Judith River group and its equivalents in other localities, we have distinct traces of the transition from Cretaceous to Eocene conditions. The Fort-Union group appears to be of Eocene age.

The Wind River and White River groups, from which a few fossils are described in this volume, are of Miocene age. The former does not belong to the Upper Missouri region; the latter is a series of sands, clays and grits, forming what are known as the *Mauvaises Terres*, or "Bad Lands" of Nebraska, and it is from these deposits, which may have a total thickness of about 1,000 feet, that the extraordinary Mammalian remains lately described by Professor Marsh have been chiefly derived. The Mollusca obtained from these deposits, which are so rich in the remains of Vertebrata, are but few—only seven are here described by Professor Meek, and all are terrestrial or freshwater species.

Of the illustrations, which occupy 45 plates, we need only say that, as in all the publications of the American Surveys, they are abundant in quantity, and for the most part excellent in quality. In fact, in every respect Professor Meek's work on the Cretaceous and Tertiary Invertebrata of the Upper Missouri is one of the finest and most complete contributions to the

palæontology of any formation that we possess, and with the previous volumes of Professors Leidy, Cope, and Lesquereux it will materially assist in solving one of the most difficult problems in the Geology of Western North America, involving the relations of the lignitiferous deposits to the well-marked cretaceous rocks underlying them.

FERTILIZATION OF PLANTS.*

IT is probably well known to most of our readers that Mr. Darwin many years ago was led to the belief that cross-fertilization was a necessary process in many, perhaps in most plants, even though the organs of the two sexes might be present together in their flowers. The prime agents in effecting this he took to be insects, and his own researches on the Orchids, the Primulaceæ, and some other groups of plants, followed by the investigations of other naturalists, both in this country and abroad, have gone far towards establishing the truth of this generalization. The means by which the cross-fertilization of plants, by the contact of the pollen of one flower with the stigma of another flower, on the same or a different plant, is provided for, are indicated as follows by Mr. Darwin in his lately published book on "The Effects of Cross and Self-Fertilization." He says: "Cross-fertilization is sometimes ensured by the sexes being separated, and in a large number of cases by the pollen and stigma of the same flower being matured at different times. Such plants are called dichogamous, and have been divided into two sub-classes: proterandrous species, in which the pollen is mature before the stigma, and proterogynous species, in which the reverse occurs; this latter form of dichogamy not being nearly so common as the other. Cross-fertilization is also ensured, in many cases, by mechanical contrivances of wonderful beauty, preventing the impregnation of the flowers by their own pollen. There is a small class of plants, which I have called dimorphic or trimorphic, but to which Hildebrand has given the more appropriate name of heterostyled; this class consists of plants presenting two or three distinct forms, adapted for reciprocal fertilization, so that, like plants with separate sexes, they can hardly fail to be intercrossed in each generation. The male and female organs of some flowers are irritable, and the insects which touch them get dusted with pollen, which is thus transported to other flowers. Again, there is a class in which the ovules absolutely refuse to be fertilized by pollen from the same plant, but can be fertilized by pollen from any other individual of the same species. There are also very many species which are partially sterile with their own pollen. Lastly, there is a large class in which the flowers present no apparent obstacle of any kind to self-fertilization; nevertheless these plants are frequently intercrossed, owing to the prepotency of pollen from another individual or variety over the plant's own pollen."

The wonderful variety of arrangements all tending towards the same end, so admirably summed up in the preceding paragraph, is sufficient, as Mr.

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* "The Effects of Cross and Self-Fertilization in the Vegetable Kingdom." By Charles Darwin, M.A., F.R.S., &c. London: John Murray. 1876.

Darwin justly remarks, to warrant us in inferring that the plants referred to derive some great advantage from the process of cross-fertilization, and his present book is a record of the long series of experiments that he has undertaken with the purpose of ascertaining whether any such advantage does accrue to the plants by intercrossing, and if so, of what nature it may be. We may add that, from his observations, he is inclined to adopt for plants in general the aphoristic statement in which he summed up the results of his investigations of the Orchids: "Nature abhors perpetual self-fertilization;" but at the same time he by no means claims to be the absolute originator of this notion, which occurred to Andrew Knight as long ago as 1799, when he said: "Nature intended that a sexual intercourse should take place between neighbouring plants of the same species;" and subsequently both Kölreuter and Herbert entertained somewhat similar views. Still earlier, in 1793, C. K. Sprengel seems to have had an indistinct prevision of the prevalence of some such law as that enunciated by Darwin.

It would be impossible, without devoting to it more space than we have at command, to give anything in the shape of an analysis of the results published by Mr. Darwin in his present book, which is a wonderful record of patient investigation, directed by an intelligence of so high an order that one feels surprised, notwithstanding what we already know of Mr. Darwin's work, to see the two qualities involved in carrying on the researches and generalizing their results so strikingly combined in the same individual. Cross and self-fertilizations of innumerable flowers had to be effected, the seeds to be sown, the plants kept distinct, measured and weighed, and all these processes were continued in many cases through several generations, and the whole of the results obtained were then tabulated in such a manner as to show the evidence furnished by them for or against the opinion which the distinguished naturalist was desirous of testing. With but few exceptions the plants raised from cross-fertilized seeds had, as Mr. Darwin expected, an advantage, and often a considerable one, over those which sprung from seeds fertilized by the pollen of their own flower; but for the particulars of the experiments, many of which, having been made upon common garden plants, may easily be repeated by any one who feels an interest in such researches, we must refer our readers to the book itself. Many important observations are scattered through the volume, and the summary contained in the last four chapters is of great interest even to those who will not be at the trouble of studying the mass of facts given in the body of the book.

BRITISH FUNGI.*

THAT a third edition of Mr. Cooke's "British Fungi" has been called for is most certainly a matter for congratulation, as it is an indication that there must be an increasing number of people to whom the study of plants, as something more than pretty things, is of interest. This new edition has undergone but little alteration, but the text furnishes a good popular account

* "A Plain and Easy Account of British Fungi, with especial Reference to the Esculent and Economic Species." By M. C. Cooke, M.A., LL D. Third Edition, Revised. London: Hardwicke & Bogue. 1876.

of the more prominent British forms; and appended to it is a tabular arrangement of genera, which, if carefully used, will enable the student to discriminate at least the genus of any ordinary Fungus that he may meet with. The illustrations are particularly good; they consist of a considerable number of woodcuts and of twenty coloured plates, the figures in which are exceedingly pretty and very characteristic. The esculent species receive particular attention.

GEOLOGY OF ENGLAND AND WALES.*

THAT Britain may fairly claim to be the birthplace and nursery of the modern science of geology, is no doubt due to some extent to the presence amongst us, during the last century, of men with special talents for geological research, but it is quite certain that the geological structure of the country has had much to do with it. It is true that Hutton and his commentator Playfair laid down the principles which are now recognized almost everywhere as the true foundations of geology; that William Smith, by his stratigraphical researches, and especially by his recognition of the value of fossil evidence in the discrimination of deposits, laid the first stone of an edifice which all subsequent workers in the same department have merely contributed to finish; but it may be questioned whether British geologists would have done so much, and held so prominent a position among the students of their science, had it not been for the peculiar advantages presented by their native island, and especially by its southern division, for the study of geological facts. Nowhere else in the world do we find so complete a series of stratified deposits brought together within so small a space. From the highest glacial and post-glacial beds down to the oldest fossiliferous deposits the British geologist may work his way practically without leaving his own country, and although his acquaintance with geology thus acquired may perhaps be a little one-sided, he will be quite prepared to appreciate and work into the framework of his personal knowledge those facts which are only revealed in other countries.

Under these circumstances it is perhaps singular that we have so few books professing to be guides to the study of the geology of a country so interesting and important. It is true that most of our manuals of geology take the structure of this country as their foundation, and treat the geology of other parts of the world as more or less subsidiary to it, so that they may, to a greater or less extent, serve as such guides; but they are generally deficient in that local definiteness, if we may use the expression, which would render them most useful to the student. The well-known "Outlines of the Geology of England and Wales," by Conybeare and Phillips, published in 1822, and to a certain extent and over a limited area the "Geology of the Thames Valley," by Professor John Phillips, which appeared in 1871, are the only

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* "The Geology of England and Wales: a Concise Account of the Lithological Characters, leading Fossils, and Economic Products of the Rocks; with Notes on the Physical Features of the Country." By Horace B. Woodward, F.G.S., of the Geological Survey of England and Wales. With Map and Woodcuts. London: Longmans, Green & Co. 1876.

general handbooks we possess in which the local element is sufficiently prominent, and the former of these has been so left behind in many points by the progress of geology during upwards of 50 years, that although still of great value as a book of reference, its statements require to be greatly modified to suit them to modern ideas.

It is therefore with great pleasure that we call the attention of our readers to the admirable little handbook of the Geology of England and Wales lately published by Mr. Horace B. Woodward, of the Geological Survey, the son of the late Dr. S. P. Woodward, whose "Manual of the Mollusca" must be well known to most of them. In this book, Mr. Woodward has brought together in systematic form the results of the best investigations that have been made in English geology, and we find that even the most recent publications have been laid under contribution. He commences with a short introduction on the principles of geology, and then proceeds at once to the description of the stratified rocks, from the Laurentian or Pre-Cambrian formations up through the long series of fossiliferous rocks, to the most recent alluvial deposits. In his classification of the older Palæozoic strata he adopts the views of Sedgwick, as lately revived by Mr. Hicks and other geologists, placing the boundary between Cambrian and Silurian at the base of the Lower Llandovery rocks. As an innovation upon generally received opinions, we may note that Mr. Woodward cuts the knot of the difficulty as to the line of separation between the Palæozoic and Mesozoic rocks, by shifting the Permians bodily into the latter series, where he makes them form, with the Trias and Rhætic beds, a primary division for which he adopts Conybeare's term "Poikilitic." In this, at all events as regards the position assigned to the Permians, we cannot help thinking that the author has made a step in the wrong direction—the fossils of the Permian series are so decidedly Palæozoic in their character, that if a line is to be drawn anywhere it ought at least to be above them.

In all other particulars we can only repeat that Mr. Woodward's book is an admirable one. That it is of necessity to a great extent a compilation will be evident to all; but there are compilations and compilations, and in the present case the author has selected the best authorities and used his own judgment in the employment of the materials they afford him, guided no doubt in many cases by his own experience gained by several years hard work in the field. Moreover, he is not content with calling on his readers to accept what he tells them, simply because he says it, leaving them to suppose that no other view is by any means admissible; but in all disputed or doubtful cases, he briefly indicates the evidence on both sides, and places the matter in such a form, that those who choose the path that he has rejected, may still make use of his lamp as a guide for their feet.

Besides describing the characters of the different formations and their divisions, including those minor subdivisions which have received local names, and indicating the localities in which exposures of the various rocks may be studied, Mr. Woodward notices the economic products of the rocks as he passes them in review, and in most cases their influence on the overlying soil. He has also a special chapter on the effect of geological structure and denudation on the scenery of the country. The fossils indicated under the different formations are not numerous, as the author says that he does

not consider long lists without figures of much use to the student, but in all cases some of the most characteristic forms are noticed.

Among the concluding chapters we have one on "Sub-aërial phenomena," such as the production of springs, caverns, peat, soils, &c.; and another on igneous and metamorphic rocks and on mineral veins. An appendix contains a glossary of geological terms, which is generally, though not quite always, correct in its definitions, and a table of the classification of the animal kingdom with special reference to palæontological purposes. The illustrations consist of diagrammatic sections and a good many very nice views; the former might perhaps be increased in number with advantage. There is also at the beginning of the volume a small coloured geological map showing very clearly the distribution of the various formations.

In conclusion we may say that Mr. Woodward's treatise will be found an excellent guide for all who wish to study the geology of this country, and at the same time it will be of considerable value to more advanced geologists who may often find it exceedingly convenient to refer to for particulars of the relations of those minor divisions in the series of deposits, the details of which are so apt to slip out of even the most tenacious memory.

AQUARIA.*

SINCE Mr. Warrington invented the aquarium, some five-and-twenty years ago, the appreciation of such means of studying aquatic animals has spread very widely, both in this country and abroad. Naturally there have been an abundance of books, good, bad, and indifferent, written as guides to the management of the aquarium and its inmates, but few of them can claim to tell their story in a more practical and at the same time pleasant fashion than Mr. J. E. Taylor in his little volume now before us. In it he gives a brief account of the history of the aquarium, followed by a chapter on the principles on which the formation of an aquarium is founded, and then proceeds to explain the management of fresh water and marine aquaria of various kinds, and the mode of stocking them with tenants, and to sketch the natural history of some of the more interesting objects, both animals and plants, which may with advantage be kept in these indoor pools. In these brief biographical sketches Mr. Taylor, after his wont, puts all that he has to say in a most readable form, but at the same time we are glad to see that he does not lose sight of the fact that the aquarium is to be regarded as a means not only of amusement but of instruction; and he loses no opportunity of indicating in what manner the supposed toy may be made subservient to the latter purpose. The little book is copiously and very nicely illustrated, and may be recommended as an admirable gift-book for any young people whose parents and guardians are not deterred by the fear of possible "messes" from encouraging in their charges a taste for the practical study of the natural history of our seas and fresh waters.

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* "The Aquarium; its Inhabitants, Structure, and Management." By J. E. Taylor, Ph.D., F.L.S., F.G.S., &c. London: Hardwicke & Bogue. 1876.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

Menhirs.—Dr. Thomas Inman has communicated to the Literary and Philosophical Society of Liverpool some notes on the mode in which gigantic stones, such as those of Stonehenge, and the menhirs of Brittany, may have been erected in the positions they now occupy. His observations are founded on the statements of the late Mr. Greey, a civil engineer, who saw a block of stone, weighing from 20 to 30 tons, carried up a hill to a height of 4,000 feet, in the course of three or four hours. This was apparently among the Khasia hills, where, according to Major Godwin-Austen, upright stones of large size are very common. The stone was fixed upon two long trees, placed parallel to each other at its two ends, and projecting for a considerable distance on each side of the megalith. Between these trees, and parallel to the stone, several cross-ties were lashed, dividing the cradle on each side into parallelograms, in each of which a considerable number of men could stand, each having a firm hand-hold upon one of the cross-ties. By taking five of the cross-ties on each side of the stone Dr. Inman reckons that there would be room for 600 bearers, which, taking the block at 26 tons, or 520 cwt., would give less than 1 cwt. for each man to carry. His informant did not count the men, but he saw them lift the frame with the block of stone and walk off with it easily to the top of a hill 4,000 feet high. Its erection when there was effected in an equally simple manner. A hole was dug where it was to stand, the lashings securing one end of the stone were cut, and the ties removed, so as to allow the end of the stone to fall into the hole; ropes were attached to the other tree and hauled upon until the stone was brought into an erect position, when the hole was filled in and the work completed. The whole process does not occupy more than three or four hours, and the work is done gratuitously, all members of the community, according to Major Godwin-Austen, being under an obligation to assist in so meritorious a work, the menhirs being generally, if not always, erected in honour of some deceased member of a tribe or family through whose influence in the other world prosperity is supposed to have accrued to the family or clan.

ASTRONOMY.

The Sun's Rotation Measured with the Spectroscope.—We have to record the most remarkable achievement yet effected with the spectroscope, though involving no discovery, at least no new result which can as yet be regarded as demonstrated. It will be within the knowledge of our readers that Secchi, having failed to recognize the effect of the sun's rotation by the spectroscopic method of measuring motions of recession and approach, expressed doubts as to the validity of the method itself. These were partly based on an erroneous estimate which in some inexplicable way Secchi had formed respecting the actual rate of the sun's rotational movement at the equator, this rate in reality amounting to only a small fraction of Secchi's estimate. Huggins also failed in obtaining spectroscopic evidence of the solar rotation, though he used a spectroscope made by Browning for Spottiswoode, (the only one of the kind ever made), on a plan devised by Proctor (the automatic battery S-shaped and twice-acting), giving a dispersive power equal to that of nineteen equilateral prisms of flint glass. The observers at Greenwich have not as yet announced the final results of their attempt to measure the sun's rotation spectroscopically, though from the general statement made by Sir G. Airy it would seem they have successfully dealt with the problem. In the meantime it has been mastered by Professor Young, of Dartmouth College, Hanover, N.H. Employing one of the marvellously effective ruled plates, made by Dr. Rutherfurd, which give diffractive spectra of singular purity, he has succeeded in unmistakably recognizing the spectroscopic effects of the sun's rotation. He regards his instrumental means with so much confidence that he relies even upon the difference between his results and those due to the direct measurement of the solar rotation. He finds the sun's atmosphere to be travelling somewhat faster than the visible solar surface. We are not sure that his confidence in this particular detail of his results is justified by the performance of his spectroscopic combination in other cases. The difference of rate, about ten miles per minute, seems too small to be measured in this way. But, in any case, it is satisfactory to find that a motion so small as that due to the sun's rotation, about one mile per second (or a difference, for opposite points of his equator, equal to about two miles per second), can be recognized by the spectroscopic method, as this enables us to regard with considerable confidence the measurements of stellar motions of recession and approach, amounting, as these often do, to twenty, thirty, or even so many as fifty miles per second.

Spectroscopic Measures of Motion at Greenwich.—The Astronomer Royal, in communicating the results of measurements of star motions, comments on objections raised by Professor Secchi. These are on the whole satisfactorily disposed of. Indeed some of Secchi's objections indicate a very imperfect acquaintance with the rules for determining the value of results obtained from a series of measurements. The measures of star motions agree on the whole fairly with those obtained by Huggins. Measures of the displacement of lines in the spectrum of the moon and Venus have been

made, to test the accuracy of the method. In the case of the moon the motion in the line of sight is insensible, and the result of the observations is in very satisfactory agreement with this. The motion of Venus has been observed at both elongations, the comparison being made in some cases with the bright lines of hydrogen or magnesium, in others with the sky spectrum. The observations of the western elongation were made in the forenoon. The calculated motions have been deduced from the daily change of distance from the earth, as given in the "Nautical Almanac." The observed motion is rather larger than the calculated, both for the approach and recession. Sir G. Airy remarks that this may be due in part to the disturbing effect of the juxtaposition of two nearly coincident lines; but it seems not impossible that we have here an indication of the fact, already shown to be deducible from the observations of the recent transit, that the sun's distance has been recently under-estimated. In Sir G. Airy's paper the sun's distance is taken as 91,260,000 miles, whereas the true distance appears to be about 92,000,000 miles. And of course our estimates of all the motions taking place within the solar system are affected in proportion to any error in the assumed distance of the sun. It is interesting to notice that we have in this spectroscopic method of measuring motions of recession and approach a means (which one day may prove exceedingly effective) of determining the dimensions of the solar system.

Many attempts were made to measure the displacement of the F. line due to the rotation of Jupiter, but for a long time these were frustrated by atmospheric obstructions. On one occasion, however, the spectrum was seen fairly well, and measures obtained which give a result in remarkable accordance with the calculated value. "It is to be remarked," says Sir G. Airy, "that the method can be applied to Jupiter with peculiar advantage, as the equatorial velocity is very large, and its effect doubled by reflexion. Thus the observed displacement corresponds nearly to four times the equatorial velocity."

In measuring the rotation of the sun the great point aimed at was to prevent the sun's heat from in any way affecting the position of the line observed, by expanding the slit unsymmetrically. The precautions adopted appear to have been sufficient, having, says Sir G. Airy, "removed the sources of error to which results by former observers appear to have been exposed." Particular care was also taken to avoid any bias from previous knowledge of the direction in which a displacement was to be looked for, the limb under observation not being determined till after the bisection had been made. "In the calculated motion," says Sir G. Airy, "there is some uncertainty, as it is doubtful how far the period of rotation deduced from sunspots will apply to the chromatosphere, to the rotation of which the observed displacement is due. There would appear to be no reason to suppose that it takes part in the general drift depending on the latitude, which has been remarked in sunspots." These spectroscopic observations at Greenwich are on the whole very satisfactory.

Spectra of the Planets.—M. Vogel has made researches upon the spectra of the planets, for which a prize has been awarded to him by the Copenhagen Academy. He finds the light of the planets in general to show the principal Fraunhofer lines. He considers the idea of a light proper to Jupiter and Saturn, as explaining their brightness, to be unfounded; for "the

"presence in the spectra of these planets of lines and bands of absorption, identical with those produced in our atmosphere, seems," he says, "to prove the existence of aqueous vapours in the gaseous envelopes of these planets, so that it seems difficult to suppose the temperature of their surface high enough to cause an emission of light." The argument is weak, however. We know that in the higher regions of our air there are often, if not generally, minute crystals of ice, forming light cirrus clouds. If an inhabitant of Venus or Mercury could become cognizant of the existence of these ice-crystals, he might infer, from M. Vogel's method of reasoning, that the temperature of the earth's surface could not be higher than the freezing point of water. He would be mistaken; and quite probably M. Vogel is mistaken, on this particular point. "The solar and the planetary spectra differ," he says, "in that the latter have absorption bands, more or less intense, in the less refrangible parts; and these may be attributed to the atmospheres of the planets. The further a planet is from the sun, the more preponderating is the influence of its atmosphere. The interior planets, Mercury and Venus, have only very weak absorption bands in the red and yellow, which are coincident with lines produced by the passage of light through our atmosphere. Mars presents the same bands, but more marked. In the spectra of Jupiter and Saturn, there is, besides these bands, a very intense band in the red; and all the more refrangible part (violet and blue) is greatly weakened, without bands being distinguishable. Lastly, the spectra of Uranus and Neptune are crossed everywhere with broad and intense absorption bands." These results agree in the main with those already obtained by Mr. Huggins. (See also an article by Mr. R. A. Proctor, "On the Condition of the Larger Planets," at p. 38 of the present number.)

Effect of Sunspots on Terrestrial Climates.—Professor S. P. Langley has endeavoured to ascertain by how many points of a degree Centigrade the earth's mean annual temperature necessarily varies between a year of maximum and a year of minimum spot areas, so far as the immediate effect of these on the solar thermal radiations is concerned. To do this, it is necessary, he says, "First to procure from experiment, trustworthy measurements of the relative amounts of photospheric, penumbral, and umbral radiation; secondly, to determine the relative photospheric, penumbral, and umbral surfaces, in a maximum and minimum year, and (having suitably combined these data) to show, thirdly, within what specific limits we can assert that the terrestrial temperature will necessarily be changed." One rather important point may be added as absolutely essential to the formation of an opinion from direct observation, viz., we must determine whether the radiation from the photosphere remains unchanged, or if not, how it varies, with the changing condition of the sun as regards the spots. It may be that the increased activity certainly prevailing when spots are numerous increases the general radiation from the photosphere, and that, too, in a much greater degree than the sunspot area reduces the extent of photospheric surface. Having unfortunately omitted to make any observations bearing on this point, probably the most important in the whole inquiry, Professor Langley's results are *pro tanto* reduced in value. They are these,—that (neglecting the point just mentioned) the least change in

solar heat due to sunspots, amounts to one-tenth per cent. of the whole radiation (whose thermometric effect registered here is a change of at least 70° C.): whence we find 0°·063 C., as the *least* change in terrestrial temperature which we can attribute to the direct action of the spots; and the *greatest* change in terrestrial temperature which can be due to this cause amounts to 0°·29 C. Thus "sunspots" do exercise a direct and real influence on terrestrial climates by decreasing the mean temperature of this planet at their maximum, but the decrease is so minute that it is doubtful whether it has been directly observed or discriminated from other changes."

Equatorial Motion with an Altazimuth Stand.—Lord Lindsay describes a method of making an ordinary altazimuth telescope follow a celestial body along a parallel of declination, which many who have used an altazimuth in astronomical observation must have thought of. It is manifest that when a telescope is sweeping a declination parallel, a point of the tube lying on a line drawn parallel to the collimating axis through the intersection of the horizontal and vertical axes, must travel in a circle having its plane parallel to the equator and its centre on the polar axis through the last named point of intersection. Its distance, therefore, from any point on this polar axis must remain unchanged. If then such a point of the tube be connected with a fixed point lying on this polar axis, the telescope will sweep a declination-parallel, if turned around the vertical axis in such sort that the connecting string remains stretched. As the length of the connecting string can be readily altered, the telescope can be made by this arrangement to sweep out any declination-circle. The idea is not a new one. It was long ago suggested by Sir G. Airy, with, however, a somewhat inconvenient arrangement, the fastening string being attached above and behind (or north of) the pivot. Lord Lindsay suggests a string attached in front (or south) of the pivot; in fact, from a point on the tube near the object-glass to a fixed point suitably placed due south of the vertical axis. In the illustration accompanying Lord Lindsay's paper the point near the object-glass is not correctly placed; it is on the tube itself, whereas the pivot (or intersection of the axes of motion) is about 1½ inch from the tube.

The Planet Vulcan.—Some excitement was occasioned among the believers in Vulcan by the announcement that in April last M. Weber, at Petcheli had seen a round spot on the sun, which a few hours later had vanished. After Wolfe, Leverrier, Moigno, and others, had expressed their conviction that this was a real transit of Vulcan, and had urged astronomers to look out for another transit in October, it was discovered that Weber's spot had been seen at the Madrid Observatory, and had been photographed at Greenwich. It was seen, however, and photographed as an unmistakable sunspot, and Weber's view of it as a round black disc which might have been a planet in transit, was due simply to the small power of his telescope. We wonder how many reported "transits of Vulcan" would thus have been explained away if a systematic observation of sunspots had been made in former years as at present?

Total Eclipse of the Moon, partly visible at Greenwich.—On the evening of Feb. 27, the moon will rise at Greenwich already partly obscured by the earth's penumbra, but the true shadow will not encroach upon the moon's disc until 1½ min. later, or at 29½ min. past 5, P.M. Total phase will begin

at 6h. 27·3m.; middle of the eclipse will occur at 7h. 15·3m.; and of total phase at 8h. 3·3m.; and last contact with the shadow at 9h. 1m., the penumbra not quite passing off until 9h. 56.7m.

Partial Eclipse of the Sun.—The partial eclipse of the sun on March 15 will not be visible at Greenwich. It will not be of any importance.

Planetary Opposition.—The only planet which comes to opposition during the quarter ending March 31 is Uranus, which will be in opposition at about 6 o'clock on the morning of Feb. 11.

New Star in Cygnus.—Early in the evening of November 24, Professor Schmidt, the director of the observatory at Athens, observed a star of the third magnitude in the constellation Cygnus in R A. 21 h. 36 m. 50·41 s., N.P.D. 47° 43′ 21·5″. At midnight its light (very yellow) surpassed that of η Pegasi, rated by Sir J. Herschel as of magnitude 3·72 (α Centauri being 1). On December 5, M. Paul Henry, of the Paris Observatory, estimated the star as of the fifth magnitude, and its colour greenish, almost blue. M. Cornu examined it unsuccessfully on Dec. 2, but on Dec. 5 he succeeded in making several measures, though much interrupted by clouds. His results are thus presented—"The spectrum of the star is composed of a certain number of bright lines standing detached on a sort of luminous background, almost completely interrupted between the green and blue, so that at first sight the spectrum appears to consist of two separate parts. In order to study it qualitatively I made use of a spectroscopic eye-piece, specially constructed, which utilizes the greatest portion of the light, and allows us to vary its concentration." Three of the bright lines observed appear to be lines of hydrogen, another line seems to be identified with the double line D of sodium, though there is nothing to prevent us from regarding it as agreeing rather with D_3, the well-known yellow prominence line. A fifth line agrees with the triple line b of magnesium. Of two remaining lines, one seems to be coincident with the line (1474 Kirchhoff) observed in the spectrum of the solar Corona and the Sierra. M. Cornu closes an interesting summary of his observations with some "mighty foolish" remarks. "Notwithstanding the great temptation there exists," he says, "to draw from facts inductions relative to the physical condition of this new star, its temperature, and the chemical reactions of which it may be the seat, I shall abstain from all comment and all hypothesis on this subject; I believe the facts necessary to arrive at a useful conclusion are wanting, or at least at a conclusion capable of verification. Whatever attractions these hypotheses may have, it is necessary not to forget that they are unscientific, and that far from serving science they tend greatly to trammel her," which proposition "we for the present content ourselves with modestly but peremptorily and irrevocably denying." M. Cornu's remarks seem intended as a reflection upon Mr. Huggins's method of treating the questions raised by the outbreak in Corona in May 1866. The hypotheses then suggested by Mr. Huggins led almost directly to the successful investigation of the solar prominences; and neither the method so successfully used by M. Cornu, nor the facts on which he bases his interpretation would have been known to men if all students of science had been content to render their direct observations as barren and unproductive as M. Cornu does his.

BOTANY.

New Colouring Matter from the Tomato.—According to M. Millardet the cells of ripe tomatoes contain a great quantity of acicular crystals of a colouring matter, for which he proposes the name of *solanorubine*. It is insoluble in water, soluble in alcohol at a high temperature, but readily soluble in bisulphide of carbon, chloroform, and benzole. It is bleached by exposure to light, possesses no fluorescence, but exhibits very characteristic absorptions in the spectrum, namely:—Two bands in the green, coinciding with *b* and F, a band between F and G, and an obscurity near G. In M. Millardet's opinion solanorubine is formed directly from the colouring matter of chlorophyll.

The Vitality of Seeds.—Professor Ernst, of Caracas, writing in a late number of the "American Naturalist," states that a curious case of vitality is afforded by a very common weed, shepherd's-purse, which, strange to say, is so rare at Caracas that it had not been met with in botanical excursions covering a period of twelve years. Two years ago, in the southern part of the garden of the monastery, a place was graded for the erection of a building. A great deal of soil was removed, and a wholly fresh surface was thus uncovered. Upon this spot many weeds sprang up, and among them thousands of specimens of *Capsella bursa-pastoris*, or shepherd's-purse. Professor Ernst concludes that in this case, the seeds had remained dormant in the soil for an unknown period. These cases belong to the same class as those mentioned by Hoffmann, and given in the January number of the "American Naturalist."

Flora of the Guadeloupe Islands.—Mr. S. Watson publishes in the "Proceedings of the American Academy of Sciences" (vol. xi.) a paper on this subject, in which he concludes that this little flora as a whole is to be considered a part of that of California, as distinct from the flora of Mexico. It may be inferred also that it has not been to any great extent derived from California by any existing process of conveyance and selection, but that it is rather indigenous to its present locality. Moreover, while it would indicate a connection at some period between the island and the main-land to the north, yet the number and character of the peculiar species favour the opinion that they are rather a remnant of a flora similar to that of California, which once extended in this direction considerably to the southward of what is now the limit of that flora upon the main-land. And, finally, the presence of so many South American types suggests the conjecture that this, and the similar element which characterizes the flora of California, may be due to some other connection between these distant regions than any which now exists, and even that all the peculiarities of the western floras of both continents had a common origin in an ancient flora which prevailed over a wide, now submerged area, and of whose character they are the partial exponents.

Sowerby's Drawings of English Fungi.—We learn from the "Journal of Botany" that the Rev. M. J. Berkeley has presented to the Department of Botany, in the British Museum, James Sowerby's original drawings for the "English Fungi," published in 1797-1809, consisting in all of 530. The

Museum already possessed the clay models made by Sowerby during the progress of the work, as well as the original drawings for the plates of "English Botany," in which it will be remembered the Fungi were not included. Mr. Berkeley's gift, therefore, very usefully completes the series of original illustrations of British plants in the Museum.

Age and Leafing of Trees.—M. A. de Candolle has an article in the "Archives des Sciences," which is thus abstracted in the "Academy." He first quotes the replies to queries on the subject from Prof. Decaisne, of Paris, and Prof. Caruel, of Pisa, who had both made observations at his request. From their observations it would seem that age had nothing to do with the date of the leafing of trees, or that the differences observable were simply individual peculiarities. In some cases the old and young trees of the same species burst their buds at the same time, while in others the older, in others the younger, developed their leaves first. But the most valuable and original material for affording some light on this subject was "a series of observations made upon two trees of the same height above the ground during fifty-seven and sixty-eight years respectively." These observations were made upon two horse-chestnut trees at Geneva, and are regarded by the learned author as perfectly trustworthy. The average date of the leafing of the one longest under observation is 94·9 days after January 1, and of the other 93·61 days. Dividing the whole term into six, four, or two periods of equal duration, the average dates exhibit no essential progression or retrogression. But it is worthy of remark that during the third period of seventeen years, 1842-58, the average is 2·5 days later than during the fourth period, 1859-75. Observations on a grape-vine, by Messrs. Macleod and Lanezweert at Ostend, from 1843 to 1875, indicate a gradual forwarding of the date of leafing. Thus, during the first period of sixteen years the average date was 16·6 days later than the average of the succeeding seventeen years. But De Candolle thinks this may be due to diminished vigour or pruning and other artificial conditions. In a word, the age of a healthy tree exercises no appreciable influence.

CHEMISTRY.

Artificial Colouring of Wine.—The adulteration of wine seems to be a growing evil in France, and, of course, after the addition of water, something is required to restore the rich colour of the clarets and burgundies. Fuchsine appears to be the favourite substance for this purpose, and French chemists are constantly bringing forward processes for its detection in wines. It is just possible that a knowledge of how to proceed in such cases may not be altogether useless even in England. The following are two of the simplest processes. M. Lamattina recommends that 100 grammes of the suspected wine should be mixed with 15 grammes of coarsely powdered peroxide of manganese, shaken for about a quarter of an hour, and filtered, when, if both the wine and the peroxide of manganese are pure, the filtrate will be colourless. But should the peroxide of manganese contain iron, which is indicated by the yellowish colour of the filtrate, any fuchsine that may be present will combine with the iron, and remain, as an insoluble compound,

on the filter. The mass on the filter must in this case be treated with alcohol, which will dissolve the fuchsine, whilst the natural colouring matter of the wine remains insoluble. M. Didelot's method is still more simple. He places a little ball of gun-cotton in a test-tube with some of the wine to be examined, shakes the whole strongly for a short time, and carefully washes the cotton in several waters; if the wine be pure, the cotton becomes white again, but the tint given to it by artificial colorants persists. The actual substance employed may generally be recognized by the addition to the coloured cotton of a few drops of ammonia. The colour is discharged when fuchsine has been used, rendered violet when the colouring matter is orchil, and greenish when it is elder juice.

Atomic Weight of Selenium.—By an investigation of numerous selenium compounds, MM. Pettersson & Ekman have endeavoured to ascertain the precise atomic weight. As a mean of seven direct analyses, they obtained the number 79·01. By reducing selenous acid by sulphurous acid, and collecting and drying the precipitate, the number 79·08 was obtained as the mean of five determinations, and this they believe to be very nearly correct. (Berlin Chemical Society, Sept. 1876.)

Physical Properties of Gallium.—M. Boisbaudran has prepared a small quantity of nearly pure gallium, and finds that its melting point is about 29·5° C. (= 85·1° F.), so that it is fused by the heat of the hand. When once liquefied, it exhibits the phenomenon of surfusion in a very remarkable manner, remaining liquid for more than a month as a globule capable of being divided and reunited by the blade of a knife, in a room of which the temperature often fell below the freezing-point. By contact with a piece of solid gallium, it was immediately solidified. It crystallizes readily, only oxidizes at the surface when heated to redness, and does not volatilize. It density is about 4·7, so that in this, as in some other respects, it stands between aluminium and indium. ("Journ. de Phys.," Sept. 1876.)

Liquid Carbon Dioxide in Mineral Cavities.—On heating a microscopic slide of quartz containing fluid cavities only to a moderate temperature, Mr. Hartley was surprised to find that the liquid, previously perfectly visible under the microscope, had disappeared. On cooling, the liquid re-appeared, accompanied by a sort of flickering movement within the cavity. Experiments on fluid cavities in various minerals made by Brewster in 1823, showed that the liquids all disappeared below 88° F., that their expansion between 50° and 80° F. was 32 times that of water, and their index of refraction 1·2946 in topaz and 1·2106 in amethyst. From these results Simmler, and later, Sorby and Butler, concluded that the liquid must be carbon dioxide. The author sought carefully to determine the critical point of the liquid, which he did by immersing the slide in water of known temperature, removing, wiping hastily, and examining. As a result, it appeared that the critical point lay between 30·75° and 31° C., that point for pure carbon dioxide having been fixed by Andrews at 30·92° C. In further corroboration of this view is the fact that when water was also present in the same cavity, the other liquid floated on it; the density of carbon dioxide being 0·83 at 0° C. and 0·6 at 30° C. Moreover, Geissler has shown the presence of this gas in quartz by its spectrum in a vacuum tube in which the quartz was broken. In explanation of the formation of these fluid cavities,

the author supposes the silica in hot solution to have come in contact with a limestone under pressure, setting free carbon dioxide, which being enclosed in the crystal cavities along with water would on cooling condense to a liquid.—("J. Chem. Soc.," xxix, 137.)

Volatility of the Alkaline Earths.—A paper was recently read before the Chemical Society by Professor J. W. Mallet on the above subject. The author has ascertained by a series of carefully made experiments that lime, baryta, or strontia heated in contact with metallic aluminium to a very high temperature in a carbon crucible, suffers an appreciable loss of weight, in some instances to the extent of more than 3 per cent., indicating that the alkaline earth must have been partly reduced and the metal volatilized. This supposition is confirmed by the observation of the flame of the carbon monoxide which is given off, the characteristic lines of the metals being distinctly visible when it is examined with the spectroscope.

GEOLOGY AND PALÆONTOLOGY.

Submarine Upheaval in Greece.—M. J. de Cigalla writes from Corfu, to the French Academy of Sciences, describing a curious upheaval of the sea bottom which has occurred in the little bay or port of Karavossera, in the Gulf of Arta. In November 1847 and February 1865, after some shocks of earthquake, a very dense sulphurous vapour issued from the bottom of the sea; this killed great numbers of fishes and other marine animals, and rendered the sea milky as far as Previsa. These sulphurous emanations still continue, especially when the wind is in the south, but they are not sufficient to cause any destruction of animals. Previous to 1847 the spot from which the emanations proceeded had a depth of 8 fathoms according to the charts, but in the spring of the present year Lieut. Miaulis, of the Greek Navy, found that the bottom had risen in the form of a cone, having a circumference of about 300 fathoms, and with its apex only 2 fathoms 4 feet below the surface of the sea. No increase of temperature was perceptible in the sea, but objects sunk at this part, and left for a time, are said to become encrusted with sulphur.

Two New British Formations.—There are certain things that demand courage, and one of them is the establishment of a new British geological formation. Nevertheless, Mr. Hicks has ventured to introduce two new divisions among those ancient rocks of the St. David's promontory, of which he has successfully constituted himself the historian. The rocks thus honoured form the central ridge of the promontory, and were formerly regarded as consisting of intrusive syenites and felstones; but, according to Mr. Hicks, this ridge is entirely composed of altered sedimentary rocks of earlier date than any Cambrian deposits, the conglomerates at the base of the latter being chiefly made up of pebbles of these rocks. In the ridge Mr. Hicks has recognized two distinct and perfectly unconformable series. The older of these, occupying the centre of the ridge, consists of quartzites and altered shales and limestones, has a N.W. and S.E. strike, and dips at a very high angle; the newer series, composed of altered shales, and having

at its base a conglomerate of pebbles from the older rock, has a strike nearly at right angles to that of the latter, upon both flanks of which it rests. Mr. Hicks has indicated certain points of resemblance between these pre-Cambrian rocks and the Laurentian of Canada, the Malvern Rocks, and others also of pre-Cambrian age in Scotland and elsewhere; but he thinks it the safest course to abstain for the present from attempting any definite correlation of them, and therefore proposes to distinguish the two series by names referring to the localities in which they occur, calling the older rocks Dimetian, from the Latin name of the district of St. David's, and the newer ones Pebidian, after the district of Pebidiog, in which they are very characteristically shown. The exposure of the Dimetian series leads him to ascribe to those rocks a thickness of at least 15,000 feet; the Pebidians are apparently of considerably less thickness, but they are in most parts more or less concealed by the Cambrian deposits which overlie them unconformably. A great mass of the Pebidian rocks is exposed to the north-west of St. David's, forming a band running nearly parallel to Ramsey Sound; and at the south-western extremity of Ramsey Island they form a bold hill about 400 feet high, on the east side of which a fault, with a down-throw of at least 14,000 feet, has brought the Arenig beds into immediate contact with the pre-Cambrian rocks. ("Proc. Geol. Soc.," Nov. 22, 1876.)

American Pterodactyles.—Professor Marsh has recognised the fact that all the known *Pterosauria*, or flying lizards of North America, which have hitherto occurred only in the Upper Cretaceous deposits of Kansas, and are remarkable for their large size, some of them having an expanse of wing of not less than 25 feet, are distinguished from their Old World relatives by an entire absence of teeth in both jaws. This is the more interesting, as it is in these very deposits that Professor Marsh has discovered the remains of birds which violate all the zoological proprieties by possessing true teeth imbedded in the jaws. Of these Pterodactyles, for which Professor Marsh has established the new order Pteranodontia, at least six distinct species, have been recognized, five belonging to the genus *Pteranodon*, which amongst other characters, presents the peculiarity of having the scapula firmly co-ossified with the coracoid, and having an oblique articular face at its distal end; and one to his new genus *Nyctosaurus*, in which the above characters are wanting. The type of the new genus was previously described by Professor Marsh under the name of *Pteranodon gracilis*. It seems to have been a middle-sized animal, measuring from eight to ten feet across the expanded wings. (Silliman's "American Journal," Dec. 1876.)

American Tertiary Mammals.—The continuation of Professor Marsh's researches upon the remains of Mammalia from the Eocene deposits of the Rocky-Mountain region has revealed a new genus of equine mammals, allied to *Orohippus*, but of an earlier and less specialized type, apparently in the direct ancestral line, for which he proposes the name of *Eohippus*. It is distinguished by having the last premolar above and below similar to the next premolar in front of it, and not like the first true molar as in *Orohippus*. The dental formula is the same in both. As in *Orohippus* the fore-foot has four, and the hind-foot three digits; but there is in addition a rudiment of the outer, or fifth metatarsal. Two species are noticed, namely *Eohippus validus* from New Mexico, and *E. pernix* from Wyoming.

Also a new genus of Porcine animals allied to *Elotherium* (Pomel), and *Helohyus* (Marsh), but differing from them in having a premolar less; the last lower molar has a distinct posterior lobe. This genus, according to the author, affords an interesting example of an extinct form outside of the ancestral line which terminated in existing pigs. The species, *Parahyus vagus*, which was about the size of the existing Wild Boar, is from Wyoming.

These pigs were probably persecuted by a carnivore about the size of a large wolf, whose remains are found in the same deposits. In its general characters this animal, which Professor Marsh calls *Dromocyon vorax*, closely resembled *Hyænodon*. It had apparently only four lower incisors, and seven lower molars, on each side, the last very small. The top of the skull had an enormous sagittal crest. Another form, belonging to the peculiarly American order Tillodontia, is described as *Dryptodon crassus*, and appears to have been about the size of a tapir. This is from New Mexico. ("Silliman's Journal," Nov. 1876.)

A new American Crinoid.—"Silliman's Journal" for July states that among the many interesting fossils recently received from the West by the Yale College Museum, is a new Crinoid from the cretaceous of the Uinta Mountains and of Kansas. No Crinoids from the American cretaceous have hitherto been described, and for the discovery of this species we are indebted to Professor O. C. Marsh, who has done so much to bring to light the geological treasures of the West. The Crinoid in question belongs to the group Astylidæ, or free Crinoids, and, as suggested by Professor Marsh in his earliest paper on the Geology of the Uinta Mountains, is allied to the genus *Marsupites* of Miller. From that genus, however, it differs widely in the number and arrangement of its plates, in having apparently ten arms, and in other characters; and it is possible that an examination of additional material may show it to be the type of an entirely new group. This point, however, cannot at present be determined. The species is named *Uintacrinus socialis*.

Origin of the Dolomites of the Tyrol.—An important essay on the above subject has been written by Drs. Dölter and Hörnes. It contains a full review of the literature of the subject, with a discussion of the various theories which have been proposed to explain the existence of the great strata of dolomite. The results of an extended chemical examination of the dolomites of the Tyrol by Dr. Dölter are given, embracing a considerable number of analyses. The authors come to the following conclusions, confirming in part the results of some earlier authors:—(1). A large number of extensive strata of limestone, weakly dolomitic, have been deposited immediately through the instrumentality of organic life in the ocean. (2). Some minor occurrences of normal dolomite are due to subsequent metamorphosis, through the introduction of carbonate of magnesia. (3). The larger part of the dolomites, whether more or less rich in magnesia, have been formed from the lime secretions of sea animals through the action of the magnesia salts contained in the sea-water (especially chloride of magnesium). Subsequent local differences have been brought about through circulating waters, dissolving out and concentrating the magnesia at different points.

METEOROLOGY.

Giant Hailstones.—Father Secchi communicated to the French Academy of Sciences (Nov. 27) an account of a remarkable hailstorm observed at Grotta Ferrata. The cloud from which it proceeded was formed with astonishing rapidity, and divided the sky into two nearly equal parts, from N.W. to S.E., advancing and unfolding itself like an immense ball of wool or cotton. The first drops of rain were of extraordinary size, at least a cubic centimeter. The hailstones, which soon followed, weighed from 40 to 60 grammes, and were composed of groups of crystals arranged round a small irregular mass of ice, having almost the appearance of groups of quartz-crystals, mostly with four or five and six faces terminated by a pyramid. Some masses obtained at Marino weighed as much as 300 grammes.

MICROSCOPY.

Diatoms in Wheat-straw.—It will probably be remembered by most of our readers that when our friends Martin Chuzzlewit the younger, and his companion Mark Tapley, located themselves in the highly salubrious city of Eden, they made the acquaintance of a certain enlightened citizen, Mr. Hannibal Chollop, whose opinion of the gentleman who sold them their allotment was expressed in the words "Scadder is a smart man." It would appear that the breed of "smart men" is not yet extinct in the United States, and that in the opinion of the Editor of the "American Journal of Microscopy," and of the Botanical Editor of Silliman's "American Journal," Professor P. B. Wilson, of Washington College, Baltimore, is a very "smart man." The article on the presence of diatoms in wheat-straw, a notice of which appeared in the October number of this Review, seems to have been rather hastily inserted, and on its coming under the notice of the Botanical Editor he wrote "pronouncing the alleged facts intrinsically absurd," but stated his belief that the author of the article had "honestly but ignorantly fallen" into a mistake, a charitable view which he has since seen occasion to alter. The editor of the "American Journal of Microscopy" is far more plain-spoken. He says: "A single glance at the engraving," of the forms of diatoms found in Col. Kunkel's straw, "is sufficient to convince any microscopist that Professor P. B. Wilson never saw 'upon the field of his microscope,' under the circumstances which he has described, the objects which he has delineated." In support of this statement he adduces two cases as follows:—"Bearing in mind," he says, "that these organisms, as figured, have been obtained by destroying the organic matter with nitric acid, we find *Bacillaria* figured as it exists only in the living condition, the frustules being joined together in the peculiar way which has given to this form the specific name *paradoxa !!!* For this diatom to have passed through a bath of nitric acid, and come out in the condition figured, would have been almost as great a miracle as the passing of Shadrach, Meshech and Abednego unscathed through the fiery furnace of Nebuchadnezzar. So, too, we find a *calcareous* foraminifer figured under the same circumstances! Verily, this *is* such a view as has

not 'fallen to the lot' of ordinary microscopists to behold, either in twenty or in four times twenty years." For the signification of these miraculous circumstances we are referred to the following passage in Professor Wilson's paper:—"The result of these investigations shows the necessity of finely divided silica in the soil, so minute as to be capable of passing with facility through the sap cells; secondly, that simple or compound silicates are useless as fertilizing agents, either natural or artificially prepared," which, as interpreted by his critic, means "*If you want to raise good crops, buy our finely divided silica.*"

The Spermatozoa of Amphiuma.—These have been examined by Dr. C. Johnston, who has contributed a paper on the subject to the "Monthly Microscopical Journal" (August, 1876). He says that "several matters of interest were observed—the structure of the spermatic particles, the dimensions of their parts, and the length of the filaments. The total length of each spermatozoon was $\frac{1}{85}$ of an inch. It begins at the moderately acute point of an elongated conical head $\frac{1}{312}$ of an inch in length by $\frac{1}{8128}$ of an inch in thickness; behind which the body, slightly more attenuate, ended almost into the vague. The 'head' presented a small curve; but the body lay straight at times, or else threw itself into serpentine flexuosities. A Tolles' recent $\frac{1}{10}$ immersion objective, with that maker's $\frac{1}{2}$-inch ocular, displayed many new points. The head, highly refractive and firmer than the other part, appeared to consist of a lamina of homogeneous substance bent along its axis, the two tumid edges of which met on the ventral side. Anteriorly these edges were suddenly bevelled away, and were lost by continuity in a delicate filament ending in a faint swelling. Posteriorly the edges contracted at the junction with the body, but were seen to be continuous with two cords which had the same relation as their originals in the head. They lay close together, and from them sprang the dorsal arch, along the ridge of which the propelling membrane was attached. This delicate film extended like a ruffle from the posterior extremity of the head as far as the caudal point; the main part was, however, invisible, but not so the margin, which was bordered with a thickened hem. In a dry preparation the spermatozoids and their details were somewhat deformed, distorted, and spread out; still the characteristics of Amphiuma's seminal particles were very manifest when studied with a fine objective. Thus the edges of the cephalic folds and the somatic cords assumed a beaded appearance, as did also the collapsed arch-fold of the back along its margin. Yet the eye was not satisfied with the dried potential male elements, and reverted with continually renewed pleasure to the moving zooids."

MINERALOGY.

New Vanadium Minerals.—Professor Roscoe has lately described ("Proc. Roy. Soc."). a new mineral containing vanadium, under the name of *Mottramite,* in allusion to one of the localities from which it has been obtained. It forms a crystalline incrustation not more than $\frac{1}{8}$ to $\frac{1}{6}$ inch in thickness, but usually much thinner, coating Keuper sandstone. Occasionally it occurs

in minute velvety black crystals, appearing yellow by transmitted light. It is also met with compact, opaque, and purplish brown. Its lustre is resinous; its streak yellow; H. = 3; sp. gr. 5·894. The analysis leads to the formula $(PbCu)_3Vn_2O_8 + 2H_2(PbCu)O_2$, in this respect analogous to erinite and dihydrite.

Professor Roscoe has also made an examination of Roscoelite (see "Pop. Sci. Rev." Oct. 1876, p. 431), and his analysis leads him to ascribe to it quite a different constitution from that given by Dr. Geuth.

PHYSICS.

Law of Refraction.—Professor Foster, at a recent meeting of the Physical Society, exhibited and described an instrument for illustrating the law of refraction. It is founded on the well-known method of determining the direction of the ray after refraction, by means of two circles described from the point of incidence as a centre, the ratio of whose radii is the index of refraction. If the incident ray be projected to meet the inner circle, and through the point of intersection a vertical line be drawn, the line drawn from the point of incidence to the point where this meets the outer circle is the direction after refraction. This principle is applied in making a self-adjusting apparatus as follows:—A rod representing the incident ray is pivoted at the point of incidence, and projects to a point about four inches beyond. To its extremity is attached a vertical rod, which slides through a nut in another rod, also pivoted at the point of incidence. The lower extremity of the vertical rod is attached to a link, so fixed as to constrain it to remain vertical. By this means the two rods always represent respectively the incident and refracted rays, and the index of refraction can be varied by altering the position of the nut through which the vertical rod passes, on the rod to which it is attached.

PHYSIOLOGY.

Vaso-motor Centres in the Cortex Cerebri.—MM. Eulenburg and Landois ("Centralblatt für die med. Wiss.," April 1876) have, according to the "Academy," discovered that the destruction of certain limited portions of the cortical substance in one hemisphere is followed by relaxation of the arterioles in the limbs on the opposite side of the body. This vaso-motor paralysis causes a rise of temperature amounting in some cases to 5°–7° C. in others to 1½°–2° C. only, and lasting from one day to several weeks. Stimulation of the same portions of the cortex by induced currents is followed by a slight and transient depression of temperature in the opposite extremities (·2° to ·6° C). The associated musculo-motor disturbances showed that these thermic or vaso-motor centres are situated in close proximity to the corresponding motor centres of the limbs. A successful attempt was made to differentiate the vaso-motor centre of the fore from that of the hind leg the former was found to lie a little to the front and to the outer side of the latter.

ZOOLOGY.

A Peripatus from New Zealand.—In the "Annals of Natural History" for November, Capt. Hutton describes a species of the curious genus of terrestrial worms, established by Lansdowne Guilding for a West Indian species under the name of *Peripatus*. Other species have been found in Chili and at the Cape of Good Hope, and hence Capt. Hutton believes the genus to be a relic of the fauna of that Antarctic Continent which, he thinks, existed during the Upper Jurassic and Lower Cretaceous periods. Its characters are very singular, apparently combining the peculiarities of the Myriopoda and the Annelida; it has a soft body and ringed legs and antennæ, but in internal structure it most nearly approaches the Annelida. The New Zealand species (*Peripatus Novæ-Zealandice*) is said to be hermaphrodite, which the others are not. Respiration is effected by tracheæ which contain irregular fibres. Capt. Hutton describes the New Zealand species as living among decayed wood, under stones, and crevices of rock. It is nocturnal and predaceous, and secures its prey, sometimes at all events, by shooting out from the oral papillæ a viscid fluid, by which flies and other insects are fastened down. It moves slowly with the body much extended and the antennæ constantly moving about as feelers. The reproduction is viviparous, and seems to go on all the year round, although the animals are half torpid in winter.

Gigantic Cuttlefish.—Professor Verrill ("American Journal," Sept. 1876), states that the organ described by him as the odontophore of the great *Architeuthis* from Newfoundland, is merely a specialized portion of the lining of the mouth or pharynx, covered with sharp chitinous teeth and granules, and that its original position is doubtful. The true odontophore is about three inches long and half an inch wide in its broadest part; the teeth are in seven rows, amber-coloured, and like those of *Loligo* and *Ommastrephes* in form. Professor Verrill also records the discovery, by Mr. Dall, of gigantic Cephalopods on the coast of Alaska. The specimens observed were thrown up on the beach, and the largest was fourteen feet in total length, but even then the extremities of the tentacular arms were wanting. The length of the body to the root of the arms was 102 inches, the arms measured from 30 to 40 inches, the slender portion of the tentacular arms was 61 inches in length, the width across the fins was 42 inches, and the diameter of the body 18 inches. From the characters of the animals, and especially from that of the few remaining suckers, the species is regarded as probably a true *Ommastrephes*, and it has been appropriately named by Mr. Dall *O. robustus*.

A Carpet Eater.—The beetles of the genus *Anthrenus* are well-known destroyers of furs, skins, and similar articles, in fact one of them was named by Linnæus *Anthrenus musæorum*, on account of the ravages committed by its larvæ in natural history collections. An American species, *Anthrenus lepidus*, Leconte, hitherto known as an inhabitant of the Western States, seems to have a special predilection for carpets, and has advanced eastwards so rapidly as to have now attained central New York, where, according to a notice in the "American Journal of Microscopy," it is known as the "Californian Carpet Moth."

A new Fish-parasite.—Under the name of *Taphrobia pilchardi*, Professor Cornalia describes* a curious parasite obtained by him from a pilchard brought to the fish-market at Nice. It is a crustacean, evidently nearly related to *Lernœonema*, but destitute of the long neck characteristic of that genus, the species of which have been found on Clupeoid fishes on our coasts, the long neck and horned-head of *Lernœonema* being represented in the new parasite by a sort of sucker, supported on a short neck, and placed on the lower surface of the body, at about one-third of its length from the anterior end. The body is nearly cylindrical in form, rather more than half an inch long, slightly narrowed and rounded off in front, and divided into three small lobes behind; from beneath these lobes spring a pair of straight egg-tubes, about two inches in length, and resembling in general character those of *Lernœonema*. The skin of the body is leathery, white and opaque, and the whole of the body, except the apical lobes, is buried in a sort of gallery in the side of the fish, in such a position that the anterior extremity with its sucking cup reaches the gills, from which the parasite apparently draws its nourishment. The two long egg-tubes, springing from the hinder extremity of the animal float freely in the water at the side of the fish. The resemblance of the parasite to *Lernœonema* is so close that it may be worth while for such of our readers as reside where pilchards are caught to watch for the occurrence upon them of the characteristic filamentous egg-tubes, so as to obtain confirmation of this curious form, which the describer regards, with some reason, as resembling at once the Lernæans and Peltogasters.

Entomology à la Mark Twain.—The following wonderful description is from the "Lacrosse Democrat." It is in some parts graphic and forcible, but, on the whole, perhaps the stiffest scientific language would be quite as intelligible. The writer had been engaged in a reconnoissance of parts of Southern Minnesota and Southern Iowa to ascertain how far the prospects for next year's crops were affected by the grasshoppers which have been for years such a pest to the Western farmers. The eggs, he found had been laid in abundance, and he remarks that as "the process by which grasshoppers deposit their eggs may be interesting to those who have never been out West to grow up with the country," he will kindly "impart the information that has cost so much labour and research." And this is how he does it. "The eggs," he says, "are found about an inch below the surface of the ground. The eggs are laid by the female hopper. When she feels as though she wanted to lighten her burden she stands upon her narrative like a dog, and begins to dig a hole with her north end. She works patiently until she has a hole in the ground about the size of a lead pencil, an inch or so deep. The hole is so near the subsequent end of the hopper that should you take her by the nape of the neck to pull her out of the hole, she would break in the middle before she would let go. After the hole is all ready the grasshopper spits on her hands and lays down her burden, which consists of material for a sack, which contains from thirty to seventy-five eggs. She covers up the hole and comes out looking as if she had been run through a clothes wringer, and with an appetite that would shame a free lunch fiend, and she attacks anything that the he-grasshopper has left in the

* "Atti Soc. Ital. Sci. Nat.," August 1875.

neighbourhood to eat." In his description of the adolescence of the young grasshopper the writer rather gives the rein to his imagination. He says: "After a few hours fooling around on the ground, the young grasshopper gets on a bush or a stalk, hangs on by his feet, and his wings begin to unfold, and in ten minutes he is ready to fly, when he goes up in the air, winks at the farmer with one eye, and goes to harvesting, without money and without price." A volume of "Episodes of Insect-life" in this highly popular style would probably be a considerable success.

The Zoology of the Caspian Sea.—The zoology of the Caspian Sea has recently been studied by Mr. Oscar Grimm, with important results. He has found in this great salt lake 120 animal species, and states that the whole number existing there must exceed 150 species. His discoveries include 6 new species of fish (a *Gobius* and five *Benthophili*), 20 species of mollusks, (*Rissoa dimidiata, Hydrobia caspia, H. spica, H. stagnalis* with two varieties, *Eulima conus, Neritina liturata, Lithoglyphus caspius, Bythinia Eichwaldi, Planorbis Eichwaldi*, sp. n., *Cardium edule* and var. *rusticum, C. caspium, C. crassum, C. trigonoides, Adacna vitrea, A. edentula, A. plicata, A. læviuscula, Dreissena polymorpha, D. caspia, D. rostriformis*, and some other terrestrial and fluviatile mollusca), a Bryozoan (*Bowerbankia densa* Farre, in which the colonial nervous system may be admirably seen), and about 35 species of Crustacea, among which we find the family Gammaridæ in particular represented by colossal forms and *Idothea entomon* in considerable quantities. Then there are 20 species of worms (*Sabellides octocirrata*), numerous Turbellaria, two Sponges (*Reniera flava*, sp. n., or perhaps a variety of *R. alba*, O. Schm., and another *Reniera* in the larval state), and, lastly, 13 Protozoa, among which are 6 new species.

Remarkable Structure of Young Fishes.—Dr. Günther, of the British Museum, has recently discovered that the young of the sword-fishes and *Chætodons* are in structure exceedingly different from the adults. In the young *Chætodon* the front of the body is shielded with large bony plates, in one species produced into three long, equidistant horns, which diverge ray-like from the body. In the sword-fishes the scapular arch is prolonged into a horn at the lower part, and the ventral fins are wanting. There is no sword, but the jaws are long, of equal length, and both are furnished with teeth. As the fish grows, the scapular horn disappears, the ventral fins grow, and the upper jaw is developed in excess of the lower. The long teeth disappear, and the upper jaw grows into the toothless, sword-like weapon which gives the fish its peculiar character.

Change of Skin in Menopoma.—Mr. A. R. Grote has observed the change of skin in that curious North American Batrachian, *Menopoma alleghaniense*. The wide mouth of the animal was opened several times to its fullest stretch, by which means the skin was parted on the lips and then rolled backward over the head. The whole cuticle was previously separated from the surface of the body, forming a sort of transparent veil, and the *Menopoma* soon withdrew its front legs from their old skin by a series of jerking moments. Then the animal moving forward, the whole pellicle was swept back by the resistance of the water until it was folded against the hind legs. The *Menopoma* then turned sharply round, and, taking the skin in its mouth, drew it over the hind legs and tail. The skin was held in the mouth for a time and finally swallowed. ("Silliman's Journal," Dec. 1876.)

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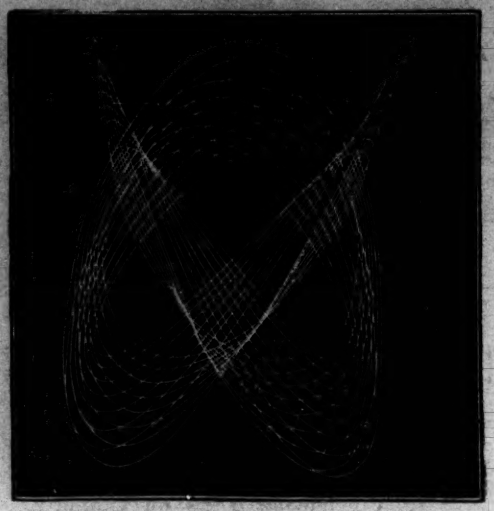

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